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ENVIRON



REMEDIAL INVESTIGATION REPORT

Eagle Zinc Company Site Hillsboro, Illinois

Submitted to:

U.S. Environmental Protection Agency, Region 5
and
Illinois Environmental Protection Agency

Submitted by:

ENVIRON International Corporation
Deerfield, Illinois

On behalf of:

Eagle Zinc Parties

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I. INTRODUCTION

A. Purpose of Report

This report summarizes and evaluates the results of the Remedial Investigation (RI) conducted at the Eagle Zinc Company site (the "Site"), located in Hillsboro, Illinois. ENVIRON International Corporation (ENVIRON) has prepared this report on behalf of the Eagle Zinc Parties (the "Parties") as part of the Remedial Investigation/Feasibility Study (RI/FS) for the Site. The RI/FS is being completed pursuant to the Statement of Work (SOW) contained in the December 31, 2001 Administrative Order on Consent (AOC) between the Parties and the U.S. Environmental Protection Agency (USEPA). All investigations were conducted in accordance with the AOC, the SOW, and the July 2002 *Remedial Investigation Feasibility Study Work Plan* (the "RI/FS Work Plan"), and certain proposals for supplementary field activities proposed by the Parties and approved by USEPA.

As stated in the SOW and RI/FS Work Plan, the overall purpose of the RI is to investigate the Site's physical characteristics, identify sources of contamination, and determine the nature and extent of contamination at the Site. Consistent with the AOC governing the RI/FS, the RI has been designed to complement the prior investigations conducted at, and in the vicinity of the Site. The primary focus of the RI is to characterize the nature and extent of contamination at the Site, to assess potential migration pathways by which the contaminants could impact human or ecological receptors, and to evaluate potential risks to those receptors. The RI includes two phases of investigation: Phase 1 (Source Characterization), and Phase 2 (Migration Pathway Assessment). The investigation results of the RI were compiled and interpreted as a basis for performing baseline human health and ecological risk assessments to establish the need for future remedial response activities for the Site.

The following documents previously submitted to and approved by the USEPA provide the basis for this RI Report:

- *Technical Memorandum, Phase 1-Source Characterization, March 2003* (the "Phase 1 Technical Memorandum")
- *Technical Memorandum, Phase 2-Migration Pathway Assessment, November 2003* (the "Phase 2 Technical Memorandum")
- *Human Health Risk Assessment, August 2004* (the "HHRA")
- *Ecological Risk Screening Evaluation, August 2004* (the "ERSE")

B. Site Background

1. Site Description

The Site is located in the Township of Hillsboro, Illinois. Hillsboro is located in central Montgomery County, Illinois, approximately 50 miles northeast of St. Louis, Missouri and 30 miles south of Springfield, Illinois. The Site is approximately 132 acres in size and is defined as the parcels of land currently owned by Eagle Zinc Company. The Site is situated on two adjoining tracts of land in the Southeast quarter of Section 1 and the Northeast quarter of Section 12, Township 8 North, Range 4 West, as well as part of the Southwest quarter of Section 6, Township 8 North, Range 3 West of the 3rd Principal Meridian. Figure I-1 presents a portion of the U.S. Geological Survey Hillsboro, Illinois 7.5-minute quadrangle, indicating the location of the Site property. Figure I-2 is a generalized Site layout map.

The Site is located in a mixed commercial/industrial/residential area in the northeastern part of Hillsboro. The Site extends from Smith Road south to an unnamed tributary to the Middle Fork of Shoal Creek. Industrial Drive extends north and south along much of the eastern property boundary. North of the Site is Smith Street, a small facility called Hayes Abrasives, a golf course, and farm fields. Industrial Drive, an asphalt company, a railroad corridor, and the former Hillsboro Glass Company facility (now a steel warehouse) are located east of the Site. Commercial/industrial facilities (University of Illinois Extension office, Fuller Brothers Construction/Ready Mix, Hixson Lumber, Hillsboro Rental, Vogel Plumbing) are located south of the Site. Undeveloped land and a residential area containing single- and multi-family dwellings are located west of the Site. The nearest residential properties are located approximately 200 feet west of the southern and central part of the Site.

It is estimated that between 10 and 15 percent of the Site is covered by buildings. Approximately 23 buildings currently exist at the Site. The types of buildings formerly used for facility operations include the office/laboratory building, manufacturing/processing buildings, equipment/raw material/finished product storage buildings, baghouses, and maintenance facilities. Other Site features include former railroad spurs, raw material and residual material stockpiles, two storm water detention ponds, a small pond in the southeast corner of the property, and several paved and unpaved roadways.

Active industrial operations at the site ceased in 2003. The site is zoned for commercial/industrial use, and local officials have indicated to ENVIRON that there are no plans to re-zone the property for other uses. The City of Hillsboro Planning Commission confirmed in 2003 its recommendation that the City of Hillsboro acquire the property for use as an industrial park. It is not certain whether or at what time such acquisition and redevelopment will occur.

2. Site History

The following information concerning the history of the Site is largely summarized from the report entitled *CERCLA Expanded Site Inspection Report* prepared by the Illinois Environmental Protection Agency (IEPA) in 1994, a September 5, 2000 letter prepared by Eagle-Picher Industries (Eagle-Picher) responding to an information request received from IEPA, a report entitled *Environmental Risk Assessment* prepared by Risk Science International in 1982, historical information sources reviewed at the Hillsboro Public Library, and discussions with Eagle Zinc Company personnel. Zinc processing operations began at the Site in 1912, at which time the facility operated as a zinc smelter under the name Lanyon Zinc Company. The smelting products included zinc and sulfuric acid. The Site was purchased by Eagle-Picher Industries in 1919. Eagle-Picher conducted zinc smelting and manufacture of sulfuric acid until approximately 1935. Sometime after 1919 and most likely during the early 1920s, the manufacture of zinc oxide and leaded zinc oxide commenced at the Site. The leaded zinc oxide was manufactured by combining basic lead sulfate (obtained from off-site sources) with zinc oxide. Additional details on the leaded zinc oxide operation are currently unavailable; however, these activities ceased around 1958. Eagle-Picher continued to manufacture zinc oxide at the Site until November 1980, at which time the Site was purchased by The Sherwin-Williams Company (Sherwin-Williams). According to Sherwin-Williams personnel, Sherwin-Williams conducted manufacturing operations for a period of less than one year. In 1984, the facility was sold by The Sherwin-Williams Company to Eagle Zinc Company, a division of T.L. Diamond & Company. Eagle Zinc predominantly continued manufacturing zinc oxide using the American process employed by Sherwin-Williams and Eagle-Picher.

ENVIRON obtained copies of historical aerial photographs covering the Site area. The following photographs were reviewed, with sources noted:¹

- Montgomery County Natural Resources Conservation Service – 1986
- Vista Information Solutions – 1973, 1987, and 1998
- National Aerial Resources – 1938, 1956 and 1968

Detailed observations made from the aerial photographs were presented in the March 2002 Preliminary Site Evaluation Report (the “PSE Report”). In general, the aerial photographs showed the progressive development of residences and industry surrounding the Site, as well as the expansion of on-site facilities, including buildings and the areas of the Site on which operations occurred.

¹ Aerial photographs from other sources investigated had limited availability or inappropriate scale.

Description of Historical Manufacturing Operations

Zinc oxide was manufactured at the Site using both direct and indirect processes. The indirect process reportedly involved the processing of zinc metal in a muffle furnace. The direct process (the American process), which was used until the plant closed in early 2003, involved the processing of zinc ores and stockpiled furnace residues in a rotary kiln furnace. While it is likely that Eagle-Picher, Sherwin-Williams and Eagle Zinc Company all used the direct process, only Eagle-Picher and Sherwin-Williams used the indirect process (muffle furnace). Residual materials historically generated by the manufacturing operations have included, among other things, rotary kiln residue, muffle dross, metallic zinc particles, and refractory bricks from the facility's furnaces. Zinc oxide is used in many applications, including the paint and ceramics industries, agricultural products, rubber products and cosmetics.

Other products historically manufactured at the Site include leaded zinc oxide (Eagle-Picher), metallic zinc (Eagle Zinc Company), and sulfuric acid (Eagle-Picher). Sulfuric acid was reportedly manufactured at the Site by roasting zinc sulfide to remove the sulfur with the southwest surface water pond used to provide non-contact cooling water. In addition, Eagle Zinc Company produced a fine-grained product that is rich in carbon by screening stockpiled rotary residues using a rotary screen and other methods.

The pyrometallurgical process known as the American process involved mixing zinc-bearing feedstocks with sized anthracite coal at the mix room. The coal was delivered to the Site by railcar; the zinc ore was delivered to the Site by railcar and truck. The furnace mix was fed into a natural gas-fired rotary furnace, 8-foot diameter by 50 foot long, at the Block 2 Furnace Building. The natural gas provided the heat source and the anthracite coal provided a reducing atmosphere to reduce the zinc feedstocks to zinc vapor. The zinc vapor was drawn from the rotary furnace into a refractory brick combustion chamber and combusted to zinc oxide by the addition of ambient air. The zinc oxide, suspended in the vapor stream (products of combustion and air), was drawn into a steel flue and a series of steel cooling loops to cool the zinc oxide and vapor stream before it was collected in a baghouse. The residue left in the rotary furnace was expelled from the rotary furnace into the discharge chamber, quenched in water and hauled to a pad for storage. The zinc oxide collected in the baghouse was conveyed to the refinery and stored in bins before refining. Based on the physical and chemical properties of the zinc oxide, bins of zinc oxide were sometimes blended while being refined. The refining process involved conveying the zinc oxide through a natural gas

fired rotary dryer in which the temperature of the zinc oxide was varied to achieve the desired product characteristics.

Until closure of the plant in early 2003, Eagle Zinc Company produced two products: zinc oxide by the American process (described above), and a carbon-rich by-product by a screening process. The facility screened stockpiled rotary residues using a double rotary screen with 1 4-inch and 2-inch screen sizes to produce the fine-grained product that was rich in carbon. This operation was conducted on a concrete pad located immediately west of the zebra building. Large and medium oversize materials created by this process were stockpiled to the west of the concrete pad.

Eagle Zinc Company also produced zinc oxide using a Waelz Kiln in the Block 3 Building as part of a pilot project. The Waelz Kiln process feedstock was the furnace residue from Block 2 and stored residue on-site. The Waelz Kiln operated like the Block 2 process where the zinc oxide is collected in a baghouse. The product collected was used as a feed for Block 2. The Waelz Kiln was not used after October 2000.

Finally, Eagle Zinc Company conducted a metallic zinc granule process in the zebra building, located in the northern part of the manufacturing plant. Crude zinc granules were conveyed to a Stedman Mill and then screened. The granule product was screened to a desired size fraction. The oversize material (metallic zinc) was collected and shipped off-site to a different zinc processing facility. The undersized fraction was zinc oxide, which was sold in bulk. This operation ceased in September 2001.

Residual Materials

For the purpose of characterizing stockpiled plant residual materials in the investigative phases of the RI, the residue piles were categorized as the following types: RR1 (Rotary Residue Type 1); RR2 (Rotary Residue Type 2); RRO (Rotary Residue Oversize); RCO (Rotary Clean Out); CPH (Carbon Plant Hutch); and MP (Miscellaneous Piles). These residue types were described by Eagle Zinc personnel as follows:

RR1: Rotary Residue Type 1 originated from the passing of feedstock through a rotary furnace under the normal American Process. Rotary furnaces 1, 2 and 4 all may have produced this type of residue. The residue is a carbon-bearing material and the non-carbon material is typically smaller than the Rotary Clean Out residue. Much of this material was processed by screening, resulting in carbon-rich material, which was sold

and/or reused on-site in the process, and oversize materials, which were stockpiled in anticipation of off-site beneficial reuse.

RR2: This material came from the Block 3 rotary kiln (now referred to as the Waelz Kiln) prior to 1979 and most likely much earlier. The feedstock that resulted in this rotary residue likely consisted of muffle dross; therefore, this material could differ chemically from RR1 residues.

RCO: Rotary Clean Out residue exhibits, for the most part, the same characteristics as Rotary Residue Type 1. It originated from the formation of a slag ring in a rotary furnace, which was removed with the use of an air hammer. Therefore, it tended to have a larger proportion of irregular shaped particles. Production of this type of residue could have occurred any time a rotary furnace was used. The frequency of furnace clean-out historically varied significantly.

RRO: Rotary Residue Oversize material consists of Rotary Residue Type 1 that was passed through a screening process. RRO most recently generated by Eagle Zinc consisted of material that was between 1/4-inch and 2 inches in size. However, RRO materials historically generated at the Site ranged in size from 1/4-inch to significantly larger than 2 inches. RRO was most recently staged by Eagle Zinc at a designated location in the northern part of the Site. This is the same location that was historically used to store RRO.

CPH: Carbon Plant Hutch residues were historically produced by a process that passed RR1 residues through a 1/8- or 1/4-inch screen. A majority of the carbon-containing material would pass through the screen and the large particles would be rejected. The carbon-rich fraction would then go through a carbon jig, which consisted of a series of two pans. Water was pumped upwards through the pans. The carbon floated at the top and the heavier material was carried along the bottom. It is the heavier material, called "hutch", which makes up the CPH residue piles.

MP: The materials referred to as "miscellaneous piles" for the purpose of sampling may have originated from the historic use of retort or Wetherill furnaces.

Regulatory History

The following information concerning the regulatory history of the Site was largely summarized from the *CERCLA Expanded Site Inspection Report*. Key events in the

operational and regulatory history of the Site are noted in the form of a timeline in Figure I-3. The facility was initially listed on the Comprehensive Environmental Response Compensation and Liability Information System (CERCLIS) on June 1, 1981 as a discovery action initiated during Sherwin-Williams' ownership of the Site. Sherwin-Williams reportedly filed USEPA form 8900-1, Notification of Hazardous Waste Site, in accordance with Section 103(c) of CERCLA, which indicated that slag had been disposed on the Site property. A Preliminary Assessment (PA) of the Site was conducted in 1984 by the IEPA pursuant to CERCLA, which culminated in the submission of a PA Report to USEPA Region V. Sampling of residual materials by IEPA in the early 1980s resulted in a determination that the materials were not hazardous waste and the Site was not subject to Resource Conservation and Recovery Act (RCRA) permitting.

In addition to the CERCLA activities described above, several sets of surface water samples were collected by the IEPA from the southwest storm water discharge between 1980 and 1982 and analyzed for metals. Detected concentrations of zinc, iron, lead and copper in the surface runoff above applicable state surface water quality standards on one or more occasion resulted in a Notice of Violation (NOV) from the IEPA. This reportedly prompted Sherwin-Williams to remove approximately 18,000 tons of residue materials from 10 acres of the Site.

A CERCLA Expanded Site Inspection was conducted by IEPA on October 26 and 27, 1993, including the collection of 28 environmental samples. The results of the Expanded Site Inspection are summarized in the following section. Based on information provided by IEPA and as reported in the *CERCLA Expanded Site Inspection Report*, the USEPA's Chief of Emergency Response for Illinois, Mr. Donald Bruce, determined that the Site did not require a time-critical or non time-critical removal action, and that the Site property did not pose an immediate threat to human health or the environment.

On May 22, 1998, Eagle Zinc Company entered into an Interim Consent Order with the Illinois Attorney General and IEPA, which contained an interim Site Plan for: (1) preparation and submittal of a Storm Water Pollution Prevention Plan (SWPPP), (2) sampling of on-site materials, (3) sampling of storm water discharges, (4) development and implementation of a ground water monitoring plan, and (5) disposal of construction and demolition debris. Pursuant to the Interim Consent Order, a monitoring well installation and ground water sampling program was conducted at the Site, which

included the installation and sampling of nine shallow monitoring wells. IEPA representatives collected split samples from the monitoring wells. This investigation culminated in the submission of the March 1999 report entitled *Monitoring Well Installation and Ground Water Sampling Interim Report* to the IEPA. Sampling of residual piles and underlying soils was also conducted pursuant to the Interim Consent Order. The results of this investigation, which also included the collection of split samples by IEPA, were submitted to IEPA in a March 1999 report entitled *Interim Report of Residue Sampling and Analysis*.

Based on the Site's discharges of storm water from two point sources, the occurrence of "regulated industrial activities" at the Site, and the facility's SIC code, the Site was determined to be subject to National Pollutant Discharge Elimination System (NPDES) storm water permitting requirements as per 40 CFR 122.26 (b)(14)(ii). A NPDES Notice of Intent (NOI) was prepared by Eagle Zinc and submitted to the IEPA. On June 20, 2000, IEPA issued NPDES Permit No. IL0074519. The NPDES permit requires: monthly monitoring of NPDES Outfall 002, preparation/implementation of a SWPPP, and submission of an annual inspection report to IEPA. A SWPPP was prepared for the Site in December 2000. The structural improvements and best management practices specified in the SWPPP included the construction of a new storm water retention system in the northeast area of the Site to allow for settling of runoff prior to discharge to Outfall 002. The storm water retention system, which consists of a two-cell retention basin, was completed in 2001. Following closure of the plant in early 2003, the IEPA issued a public notice of the termination of the facility's NPDES storm water permit on May 23, 2003, which stated "the facility has closed, all industrial activity has ceased, and the discharges have ceased."

The removal of a 500-gallon gasoline underground storage tank (UST) in April 1998 resulted in the reporting of a Leaking UST (LUST) incident to IEPA, because a limited amount of impacted soil was observed in the tank excavation and a pin-size hole was observed in the tank itself. No free-phase gasoline or ground water was observed in the tank excavation. No contaminated soil was excavated or transported off-site. The location of the former UST is shown on Figure I-2. The monitoring wells used for the UST investigation (MW-A, MW-B, MW-C/G-106, MW-D and MW-E) are also shown on Figure I-2.

To address the LUST incident, site classification and assessment activities were performed by Goodwin-Brom, Inc. (GBI) and Philip Services Corporation (Philip),

including: (1) screening of soil samples collected from soil borings using a photoionization detector (PID)², (2) collection of a soil sample for laboratory analysis of benzene, toluene, ethyl benzene and xylenes (BTEX), (3) collection of soil samples for particle size analysis, (4) installation of four new monitoring wells, (5) sampling of five monitoring wells for BTEX compounds³, (6) completion of slug tests to estimate hydraulic conductivity, and (7) completion of a well search. Neither the soil sample, nor any of the ground water samples collected from the monitoring wells to date have contained detectable concentrations of BTEX compounds. Based on these results and discussions with IEPA, the LUST incident was classified as "low priority" and ground water in the former tank area was monitored periodically for three years⁴. As there were no detections of contaminants above applicable ground water standards, the IEPA issued a No Further Remediation (NFR) letter for the former UST on August 31, 2004. The ground water monitoring program associated with the former UST was completed independently from the RI FS.

3. Previous Investigations

Several environmental investigations were conducted on-site and in adjacent off-site areas since the early 1980s and before the initiation of the RI in 2001. These investigations are summarized in Table I-1. The data generated by the previous investigations were summarized in the PSE Report. Comparison of the previous data with site-specific background data collected during the previous investigations and regional background values were used in the preliminary identification of potential contaminants of concern (PCOCs) and potential areas of concern (PAOCs). The previous investigations are described below for each environmental medium investigated.

Soil

The 1982 Environmental Risk Assessment report prepared by Risk Science International (RSI) presented the results of soil samples collected at various locations on the Site property in October 1980. RSI's report states that the soil samples did not contain concentrations of metals significantly above background soil samples collected in the Hillsboro area. Concerning the soil data noted in RSI's report, all of which were collected by others prior to RSI's risk assessment, the 1982 report concluded: "much of the lead, cadmium, copper, and zinc, although high in concentrations in the dross, kiln residues and ore spoils, appears to be relatively inert and fixed in these materials." As

² The soil screening included the soil borings for wells MW-A through MW-E, as well as a soil boring completed to a depth of 5 feet below grade located 20 feet west of the former UST.

³ Pre-existing well G-106 was designated MW-C and sampled as part of the UST investigation.

⁴ Quarterly during the first year, semi-annually during the second year, and annually in the third year.

discussed in the PSE Report, an accurate location map for the soil samples collected by RSI was not available to ENVIRON for review. Therefore, the soil data collected by RSI were not included in the preliminary evaluation of Site soil data presented in the PSE Report and the conclusions made by RSI are discussed herein for informational purposes only.

The Expanded Site Inspection conducted by IEPA in October 1993 included the collection of 18 soil samples: a background sample and duplicate sample collected from a location in the nearby town of Butler; and 16 samples collected at various off-Site locations. All soil samples were collected from the ground surface (0-4 inches below grade) and analyzed for Target Compound List (TCL) inorganic compounds.

In May 1998, 44 soil samples were collected by GBI at 25 on-Site boring locations. In addition, 6 split samples were collected by IEPA representatives. The boring locations were grouped within four Site areas, which were designated Areas 1 through 4. Between one and three samples were collected from each of the soil borings, which generally extended to the depth at which native clay was encountered. All soil samples were analyzed for lead and cadmium, with selected soil samples also analyzed for Toxicity Characteristic Leaching Procedure (TCLP) lead and TCLP cadmium.

Sediment

Eight sediment samples were collected by IEPA as part of its October 1993 Expanded Site Inspection. Three of the samples were collected on-Site. The remaining samples were collected at off-Site locations in the eastern and western drainageways. A background sample and a duplicate sample were collected from an unnamed tributary to Middle Fork Shoal Creek, upgradient of the point at which NPDES Outfall 001 discharges to this tributary. All sediment samples were analyzed for the full TCL, including both organic and inorganic compounds.

Residues

Two samples of residue piles were collected by IEPA as part of the 1993 Expanded Site Inspection and 68 samples of residue piles were collected by GBI in May 1998, with split samples collected by IEPA. The samples collected by IEPA in 1993 were analyzed for TCL inorganics; the samples collected by GBI in May 1998 were analyzed for lead and cadmium, with selected samples analyzed for Toxicity Characteristic Leaching Procedure (TCLP) lead and TCLP cadmium. The residue samples collected by GBI represented 15 discrete stockpiles that were categorized as the following types: RRO

(Rotary Residue Oversize); RR1 (Rotary Residue Type 1); RR2 (Rotary Residue Type 2); RCO (Rotary Clean Out); CPH (Carbon Plant Hutch); and MP (Miscellaneous Piles).

Surface Water

Storm water samples were collected from the outlet for the southwest pond (general area of current NPDES Outfall 001) for laboratory analysis of inorganic constituents on four occasions between 1980 and 1982. Data were available for two of these sampling rounds: November 19, 1981, and March 23, 1982.

On June 9, 1998, pursuant to the Interim Consent Order with the IEPA, first flush and composite samples were collected from Outfall 001 by GBI and analyzed for metals and other inorganic parameters, and on June 29-30, 1998, GBI collected first flush and composite samples from Outfall 002 and analyzed the samples for metals and other inorganic parameters. These samples were collected prior to the installation of an engineered storm water retention basin to capture storm water prior to it being discharged to the eastern drainageway. In 2000 and 2001, the facility sampled Outfall 002 on a monthly basis⁵ as required under the NPDES permit, which regulated the Site's storm water discharges. The analytical parameters for the monthly sampling rounds were total suspended solids, sulfate, cadmium, and zinc.

Finally, ENVIRON obtained analytical results for several rounds of surface water samples collected from Lake Hillsboro by IEPA's Division of Public Water Supply between April and October 2001. The samples were collected from the area of the City's potable water intake, which is located near the dam for the reservoir, approximately one mile north of the Site. The samples were analyzed for metals, pesticides, and certain inorganic and physical parameters.

Ground Water

In December 1998, GBI collected ground water samples from nine shallow on-Site monitoring wells. The samples were split with IEPA and analyzed for 35 IAC Part 620.410 inorganic and organic parameters.

As discussed above, four monitoring wells were installed by GBI in the area of a former 500-gallon gasoline UST that exhibited evidence of leakage. The sampling results,

⁵ No monthly samples were collected during periods when storm water is not discharging from Outfall 002.

which indicated no detectable BTEX compounds, show that ground water has not been impacted. As these data were not collected to assess environmental conditions on the Site as a whole and were all non-detect, neither the data nor the on-going UST monitoring program were discussed in any of the RI documents. Based on their locations and relative spacing, none of the monitoring wells installed for the purpose of evaluating potential impacts from the tank (i.e., MW-A, MW-B, MW-D, and MW-E) were used during the RI. As noted above, an NFR letter dated August 31, 2004 was issued by IEPA for the former UST.

C. Report Organization

Section II describes the physical characteristics of the areas investigated as part of Phases 1 and 2 of the RI. Section III of this report provides a summary of the work conducted as part of the Phase 1 RI and nature and extent of contamination determined based on the Phase 1 investigations. Section IV of this report provides a summary of the work conducted as part of the Phase 2 RI and nature and extent of contamination determined based on the Phase 2 investigations. Section V of this report provides a Site Conceptual Model, compiled following completion of the Phase 2 investigation. Section VI presents the Human Health Risk Assessment. Section VII presents the Ecological Risk Screening Evaluation. Finally, Section VIII presents conclusions based on the findings of the RI.

II. PHYSICAL CHARACTERISTICS OF THE STUDY AREA

The physical characteristics of the areas of the Site were discussed in detail in the PSE Report and the Phase 1 and Phase 2 Technical Memoranda. This information was assembled through inquiries made during completion of the Preliminary Site Evaluation, the Phase 1 investigation, the Phase 2 investigation and from previous environmental reports concerning the Site.

A. Surface Features

The Site's surface topography, storm water drainage, water bodies, and physiographic setting are described in detail in below. The historic plant residues are discussed in Section I.B.2 above. A topographic survey map of the Site is included as Figure II-1. The locations of residue piles are depicted on Figure I-2. The thickness of any residues encountered at each well/piezometer location is depicted on soil boring logs presented in Appendix III-1.

B. Local Meteorology

The following information on the climate of Hillsboro, Illinois was obtained from on-line sources of historical weather data. The climate of Montgomery County is considered continental and temperate. The summer months are hot and humid with an average temperature of 75° Fahrenheit (F) and an average daily high temperature of 87° F. The winter months are moderately cool with an average temperature of 31° F and an average daily high temperature of 40° F. Rainfall is well distributed throughout the year, with the highest average rainfall in May. Total annual precipitation for the area is approximately 41 inches. Approximately 57 percent, or 23 inches, of the total annual precipitation occurs as rain from April through September and coincides with the growing season. The average total snowfall accumulation is approximately 18 inches.

The following information is for Springfield, Illinois, which is located approximately 30 miles north of Hillsboro, but is expected to display similar weather conditions. The average relative humidity is 83 percent in the morning and 63 percent in the afternoon. With the exception of January, the prevailing average wind direction throughout the year is from the south. In January, the average wind direction is from the west-northwest. The average wind speeds are greatest in January, March, April, and November, at 13 miles per hour (mph). The lowest average wind speeds are in July and August, at 8 mph. ENVIRON obtained a wind rose diagram for the Springfield, Illinois airport, which displays the dominant average wind directions and ranges of wind speed for the year 1987 (Appendix II-1). Consistent with information obtained from other sources, the rose diagram indicates that the dominant wind direction is towards the north and northeast, with moderate frequency in other eastward directions, and the lowest frequencies in the westward directions.

C. Surface Water Hydrology

The surface topography of the Site is relatively level, with surface elevations ranging from about 600 feet above mean sea level (msl) at the southwest retention pond to about 635 feet above msl in the central portion of the Site. The predominant topographic slope of the Site is southerly. Three surface water ponds exist at the Site: a southwestern storm water retention pond; an engineered storm water retention pond located near the eastern Site property boundary; and a small pond located in the southeastern part of the Site. The southwestern storm water pond receives a large proportion of the Site's storm water runoff. Storm water intermittently discharges westward from this pond to a drainage swale, which in turn discharges to an unnamed tributary of Middle Fork Shoal Creek. This outfall was previously permitted with the IEPA's Division of Water Pollution Control as NPDES Outfall 001. Middle Fork Shoal Creek flows southwestward and joins Shoal Creek approximately six miles southwest of the Site.

Storm water that originates in most of the manufacturing areas and the eastern part of the Site enters an engineered storm water retention system located near the eastern property boundary. The storm water retention system includes a small concrete settlement structure and a two-cell, clay-lined retention pond. This system was designed to provide adequate detention time to clarify the water prior to discharge. Storm water generally evaporates from the retention basins, and was previously used as make-up water for the plant's non-contact cooling system. However, periodically, storm water discharges from the retention pond to a drainage swale (designated NPDES Outfall 002), which channels the storm water off the Site property to the east. The drainage swale extending from Outfall 002 discharges to Lake Hillsboro, approximately 1/2-mile east of the Site. Lake Hillsboro is a man-made reservoir, which discharges to Middle Fork Shoal Creek approximately one mile north of the Site.

The southeastern pond is located between two railroad spurs near the entrance to the plant. This pond does not appear to receive storm water runoff and has no inlet or outlet.

In addition to the drainage pathways noted above, storm water that collects in a limited area along the southern Site boundary discharges to a small stream located south of the Site. This stream joins the drainage swale that originates at Outfall 001 just west of the southwest Site property line.

D. Site Geology

According to Illinois State Geological Survey (ISGS) publications, the Site is located within the Central Lowland Physiographic Province of Illinois. Within this province, the Site lies within the Springfield Plain Division of the Till Plains Section. This area is characterized by Pleistocene glacial till and outwash deposits derived from the Illinoian Stage glacial episode.

According to the map entitled Thickness of Glacial Drift in Illinois (ISGS, 1975), the Site is underlain by between 50 and 100 feet of Pleistocene-age unconsolidated glacial deposits. The surface deposits in the area of the Site consist of up to 5 feet of loess, which are wind-blown

deposits generally consisting of silt. According to the map entitled *Quaternary Deposits of Illinois* (ISGS, 1979), the site is underlain by the Vandalia Member of the Glasford Formation. This unit consists of hard, compact sandy or silty till. According to maps contained in the document entitled *Potential for Contamination of Shallow Aquifers in Illinois* (ISGS, 1984), the geologic materials underlying the Site are classified as Type E, which is described as "uniform, relatively impermeable silty or clayey till at least 50 feet thick, with no evidence of inter-bedded sand or gravel". This description is verified by soil boring and monitoring well installation logs prepared by GBI as part of a ground water investigation conducted at the Site in November 1998 and by ENVIRON as part of Phases 1 and 2 of the RI. In general, the soil boring logs indicate that, except in areas with thick deposits of historic plant residues, clay, silty clay and sandy clay extend to a depth of at least 15 feet below ground surface (bgs) throughout the Site.

According to the *Geological Map of Illinois* (ISGS, 1967), the glacial deposits are underlain by bedrock consisting of the Pennsylvanian-age Bond Formation. This unit is between 100 and 300 feet thick and predominantly consists of limestone, with some layers of shale and sandstone.

E. Site Hydrogeology

Shallow ground water contour maps were constructed by ENVIRON using water level measurements made by GBI in December 1998 and by ENVIRON in March 2003 and June 2003. GBI collected water level measurements from all 13 on-Site wells. The inferred shallow ground water flow direction generally varies across the Site - southwestward in the southwest part of the Site, to southward and southeastward in the northern and central portions of the Site. Based on the ground surface elevations at the monitoring wells, the inferred pattern of shallow ground water flow generally reflects the Site topography. The shallow ground water flow pattern beneath the site is discussed further in Section IV.B.1.

Site activities conducted by Philip as part of the UST investigation completed at the Site in 2000⁶ included the completion of four slug tests within monitoring wells installed in the southeastern portion of the Site. The slug tests indicated hydraulic conductivities in the shallow water-bearing zone that ranged from 1.11×10^{-4} centimeters per second (cm/sec) to 8.54×10^{-5} cm/sec. These measurements are within the ranges of hydraulic conductivity generally reported for both glacial till and loess.

ENVIRON submitted a request to the IEPA for a one-mile radius search of potential water supply wells and conducted an on-line search of well records maintained by the Illinois Department of Natural Resources (IDNR). The IEPA's Department of Public Water Supply reported that no community water supply wells are located within 2,500 feet of the Site boundaries. Several domestic wells were reported by the Illinois State Water Survey (ISWS) as being located within a

⁶ As documented in a report entitled *Site Classification Completion Report*, dated September 13, 2000.

one-mile radius of the Site. The results of the well search requested by ENVIRON, including the IDNR well records and ISWS one-mile radius plot, are discussed in detail in the PSE Report.

ENVIRON also reviewed the results of well searches previously conducted for the Site by Philip. The ISGS provided Philip with a survey map and well records for several domestic wells located in the general vicinity of the Site. In addition, the ISWS indicated 4 shallow monitoring wells and 3 shallow domestic wells in Section 1 of T8N, R4W, where the Site is located. The information provided by ISGS and ISWS was included in the PSE Report.

The City of Hillsboro has been served by a municipal potable water system since the existing water treatment plant was constructed in 1926. While the well searches indicated records of some older domestic wells located within a one-mile radius of the Site, all residents of Hillsboro, as well as unincorporated areas located within one mile of the Site, are provided with public water.

Specifically, the ISWS search showed a group of private wells located in an area immediately west of Lake Hillsboro. According to Hillsboro's Mayor, Hon. William Baran, this area, known as Lakewood Knolls, was connected to the public water supply during the 1980s and 1990s, either at the time the homes were built, or later, when the municipal water lines were installed in these areas. The small older residential area located in the same area, but south of Smith Road, is also supplied with public water. According to a local ordinance, "...any connection whereby a private, auxiliary or emergency water supply other than the regular public water supply enters the supply or distribution system of the City..." is prohibited. According to Mr. Scott Hunt of Hurste-Roche, Inc., the City's engineering firm, the prohibition of cross-connections would preclude the use of a separate domestic well water system within a household that is connected to the municipal water system. Although local officials have indicated that some older domestic wells may be used for non-potable outdoor purposes (e.g., watering lawns and gardens), it is unlikely that ingestion of water from these non-potable wells occurs, and there is no expectation that ground water resources will be developed for potable use in the foreseeable future.

In addition, Mr. Robert Kirk, Director of Public Health for Montgomery County, was contacted by ENVIRON concerning the potential existence of public or private water wells in the vicinity of the Site. Mr. Kirk indicated that although there are no local ordinances prohibiting the use of private wells, all residents of Hillsboro are provided with public water, which is obtained from Lake Hillsboro and Glen Shoals Lake. ENVIRON confirmed with Mr. David Booher, Water Superintendent for Hillsboro, that the City does not have any public water supply wells.

Finally, ENVIRON conducted a drive-by reconnaissance of properties adjoining the Site. ENVIRON did not observe any water supply wells on these properties. As discussed in the approved HHRA, potable use of ground water was evaluated, and concluded on these bases with USEPA's concurrence to be an incomplete exposure pathway.

F. Demography and Land Use

According to the 2000 census, approximately 2,800 people lived within a one-mile radius of the Site and approximately 9,300 people lived within a five-mile radius of the Site. Land use characteristics of the Site and surrounding area are described in Section I.B.1 above.

G. Ecology

According to the National Wetland Inventory Map for Hillsboro, Illinois (U.S. Fish and Wildlife Service, 1988) the only mapped wetlands on the Site property include the southwest retention pond and the small pond located in the southeast part of the Site. These ponds are mapped as "intermittently exposed palustrine wetlands with unconsolidated materials in diked or impounded areas". According to the Federal Emergency Management Agency (FEMA) Flood Hazard Boundary Map for Montgomery County, Illinois (1991), no portions of the Site or the off-Site areas planned for investigation are located within either a 500-year or 100-year flood zone. Detailed descriptions of the ecology of the Site and adjacent drainageways are provided in the ERSE (Section VII).

III. PHASE 1 – SOURCE CHARACTERIZATION

A. Study Area Investigations

The Phase 1 field activities were conducted at the Site between July 8, 2002 and July 19, 2002. All field activities were conducted and/or supervised by ENVIRON. All soil borings and test excavations were conducted by Philip Services, Inc. (Philip). All laboratory analyses were conducted by EnChem, Inc. (EnChem) of Green Bay, Wisconsin. Site surveying work was conducted by Hurst-Rosche Engineers, Inc. of Hillsboro, Illinois. A preliminary ecological field survey was also conducted at the Site as part of the ERSE. The results of this and subsequent ecological field surveys are documented in Section VII.

1. Site Surveying

All surveying was completed by Hurst-Rosche Engineers using a Global Positioning System (GPS) based system. The first task completed was the surveying of the pre-selected locations of 130 soil borings. Each boring location was marked with a stake and northing, easting and elevations were recorded. Based on field observations, some soil boring locations were adjusted the minimum practicable distance to allow drill rig access. Hurst-Rosche also completed the topographic survey of the Eagle Zinc property initiated in 1998 and located the Site property boundaries. The completed topographic survey map was included in the Phase 1 Technical Memorandum.

2. Soil Investigation

As discussed in the RI/FS Work Plan, soils in the following areas of the Site were investigated in Phase 1:

- The on-Site areas previously defined as Areas 1 through 4;
- On-Site areas located north and west of the manufacturing plant which were not sampled prior to the current RI (the “Northern Area” and “Western Area”, respectively); and
- The manufacturing plant area (the “Manufacturing Area”).

A total of 130 soil borings were completed in on-Site areas to characterize the nature and extent of organic and inorganic contaminant concentrations in soils (Figure III-1). Soil boring locations were determined in each area by randomly selecting sampling locations from an orthogonal grid, as discussed in the RI/FS Work Plan. The majority of soil borings were completed in the areas west and southwest of the manufacturing plant (Areas 1 through 4), on which raw materials and residual materials were historically stockpiled. Twenty-five (25) soil

borings were completed in each of Areas 1 through 4. Soil borings were also completed in the manufacturing plant area and in the historically undeveloped northern and western portions of the site property. Ten (10) shallow soil borings were completed in each of these three areas. Figure III-1 shows all soil boring locations and Table III-1 provides details concerning the soil borings, including PID measurements.

Soil borings performed during the Phase I investigation were completed using a direct-push drilling apparatus (e.g., Geoprobe) equipped with 4-foot-long, 2-inch outside diameter macro-core samplers with dedicated polyethylene liners. All soil borings were sampled continuously from the ground surface to the completion depth. The completion depth was either 4 feet below ground surface (bgs) or two feet below the depth at which undisturbed⁷ native soils were encountered, whichever was determined to be deeper. An experienced ENVIRON field engineer prepared a geological log for each soil boring. Soil boring logs are included in Appendix III-1. Field screening for organic vapors was conducted using a PID immediately after sample retrieval. In addition, each soil core was screened for metals concentrations using a hand-held portable X-ray fluorescence (XRF) analyzer. A stainless steel spoon was used to prepare a flat surface to take the XRF readings directly from the soil core. Two PID and XRF measurements were made from the upper portion of undisturbed native soil within the soil core. All PID and XRF measurements were made from soils collected at depths greater than 1 foot bgs. The shallower measurement was taken from the uppermost interval of undisturbed native soil and below any residue materials. The deeper measurement was taken one to two feet below the shallower measurement. The actual depths of the field measurements varied, depending on the thickness of any surface residues. Table III-1 provides the thickness of surface residues encountered in each boring.

All samples collected for laboratory analysis were obtained from the uppermost one-foot interval of native soils exhibiting undisturbed characteristics. As shown in Table III-1, in all cases, sample depths were greater than 1 foot bgs. The XRF screening results were used to select which soil samples were retained for analysis of Target Analyte List (TAL) metals at the EnChem laboratory. Samples from 20% of the soil borings completed (a total of 26 samples) were retained for fixed-base laboratory analysis of TAL metals. The samples selected for laboratory analysis were generally those exhibiting the highest XRF screening results, as represented by the sum of the concentrations of the PCOCs identified for soil, sediment and residues in the RI FS Work Plan.⁸ The raw XRF screening data are presented in Appendix III-2.

⁷ Includes soils exhibiting no visually observable evidence of disturbance or mixing with surficial materials, such as historical plant residues.

⁸ Antimony, arsenic, cadmium, lead, silver, and zinc.

PID results were used to determine which samples were analyzed for the TCL of organic compounds, including volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), as well as polychlorinated biphenyls (PCBs). Table III-1 presents the PID screening results for soils. No PID readings above ambient background levels were measured from any of the soil cores screened and no visual evidence of soil contamination was observed (e.g., staining). Therefore, as described in the RI/FS Work Plan, the locations of the soil samples for laboratory analysis of TCL organics and PCBs were randomly selected from the borings selected for the TAL metal analyses. To collect the samples for TCL organics and PCB analysis, an additional boring was advanced immediately adjacent to the original boring location and the same soil boring/sample number was used. The samples retained for laboratory analysis of TCL organic compounds and PCBs were collected at the same depth as the original borings. Samples from 10% of the soil borings completed (a total of 13 samples) were retained for analysis of TCL organic compounds and PCBs.

Because the decision as to which borings would be sampled for TAL metals from each area could not be made until all borings in that area were completed, soil from the uppermost one foot of undisturbed soil from each soil boring was placed in a zip-locked bag, labeled and stored in a cooler on ice. Upon completion of all soil borings in a given area, the XRF data was evaluated and a decision was made as to which samples would be retained for laboratory analysis of TAL metals. Following this determination, the soil that had been stored in zip-locked bags was placed in a laboratory prepared sample jar, labeled, and placed on ice for shipment to the laboratory.

Field duplicates were collected from samples S-NA-9-2 and A4-15-2 (rate of 1 duplicate per 20 soil samples) and submitted for laboratory analysis. The field duplicates were analyzed for TAL metals or TCL organic compounds plus PCBs, depending on the original sample analyses. Samples A3-23-2 and A2-7-3 were designated as a Matrix Spike/Matrix Spike Duplicates (MS/MSDs). Table III-1 shows XRF and PID screening results for the soil borings and the borings/depths selected for laboratory analysis. Figure III-1 shows the locations of borings at which soil samples were retained for laboratory analysis.

3. Sediment Investigation

A sediment investigation was conducted in on-Site and off-Site portions of the storm water/surface water drainageways that receive storm water discharges from the Site, border the Site, and enter the Site from adjacent upgradient properties. The samples were collected as grab samples in sediment accumulation areas at representative locations in the drainage ditches/streams. The principal objective of the sediment investigation was to characterize the nature and extent of metals impacts on sediments in the drainageways and to determine upgradient background concentrations.

As described in the RI/FS Work Plan, 16 sediment samples were collected for fixed-base laboratory analysis, including 6 samples from the eastern drainageway, and 10 samples from the western drainageway. As shown on Figure III-2, 13 of the sediment samples were collected downgradient of Outfall 001 or Outfall 002, or at locations that may receive storm water runoff from the site (e.g., SD-WD-8). The remaining three sediment samples (SD-ED-11, SD-WD-5 and SD-WD-10) were collected to investigate upgradient or background conditions in the drainageways or areas not believed to have been impacted by the Site.

The following procedures were used to collect sediment samples for laboratory analysis. A sample of the stream sediment was obtained using stainless steel sampling tools, none of the sediment sampling locations required collection of sediment samples through a water column.⁹ All samples were collected from the uppermost six-inch interval of accumulated sediments. Each sample location was screened for organic vapors using a PID. After completion of field screening at all sediment sample locations, samples were collected for laboratory analysis from undisturbed sediments immediately adjacent to the PID screening locations. Upon completion of sampling, the geographic coordinates of each sediment sample location were logged using a hand-held GPS unit. The sampling generally proceeded from downstream to upstream to minimize any impacts from disturbed sediments.

All sediment samples were analyzed for TAL metals. In addition, four of the sediment samples (25 %) were analyzed for TCL organic compounds and PCBs.¹⁰ A field duplicate sample was collected from sample SD-WD-9 and submitted for laboratory analysis of TAL metals, TCL organic compounds, and PCBs.¹¹ In addition, sample SD-ED-12 was designated as a MS/MSD. Table III-2 provides a summary of the sediment sampling locations and samples retained for laboratory analysis.

4. Residue Investigation

Each residue pile or group of piles, identified by type of material, physical appearance, or spatial considerations, was evaluated by collecting representative samples in accordance with SW846 procedures and testing the samples for metals at a fixed-based laboratory using two leaching tests: the Toxicity Characteristic Leaching Procedure (TCLP); and the Synthetic Precipitation Leaching Procedure (SPLP). The residue samples were collected from trenches

⁹ As discussed in the RI/FS Work Plan, surface water flow in the upper reaches of the drainageways (i.e., those segments located on-site or close to the site) is intermittent. Surface water was present at all sediment locations except for SD-ED-11, SD-ED-14 and SD-ED-15. At these locations, the sediment samples were collected from exposed portions of the stream bed or from exposed "islands" within the stream bed.

¹⁰ As none of the sediment samples exhibited above-background PID readings or other field evidence of contamination, the samples selected for organic analyses were those located closest to, yet downgradient of the manufacturing area (i.e., samples SD-ED-12, SD-ED-13, SD-WD-7 and SD-WD-9/9D).

¹¹ As none of the downgradient sediment samples exhibited above-background PID readings or other field evidence of contamination, the field duplicate sample was collected at SD-WD-9, the on-site sediment sampling location with the greatest potential for site impacts.

excavated to the base of the piles. A total of fifteen (15) residue samples were collected and analyzed.

During inspections performed at the on-set of the Phase 1 field activities, certain piles were grouped together for sampling purposes based on size, type, and proximity. In addition, some additional piles were identified (new piles designated as "NP"), and some of the previously identified piles were processed on-site by the facility to produce a zinc and carbon-rich product, resulting in additional Rotary Residue Oversize (RRO) type piles. As such, the final number and locations of the sampled piles differed slightly from the locations depicted in the RI/FS Work Plan. Table III-3 provides information concerning the piles initially identified for potential sampling in the RI/FS Work Plan, the piles or pile groups actually sampled (including rationale for combining certain piles for sampling), and the residue types represented by the piles. Figure III-3 shows the residue piles and associated sample designations. One gross sample was collected from each discrete residue pile or group of piles of the same type. Each gross sample was collected as a composite of several sample increments. Based on tabulated values of the Student's "T" statistic contained in SW-846, six sample increments were composited into a single gross sample for each pile or group of piles. The locations of the sample increments were spaced evenly across the horizontal extent of each pile.

A test excavation or trench was completed at each of the six sample increment locations, extending through the entire thickness of the pile. Equal-volume samples were collected from the bucket of the excavator at three depths from within the excavation: approximately one-quarter, one-half, and three-quarter depths from the top of the excavation. The visual appearance of each sample was logged, including color, composition, and estimated particle size(s). The three samples collected from the excavations were mixed thoroughly to create the six sample increments. The six sample increments were then mixed thoroughly to produce the gross sample for the pile(s). Mixing of the samples was conducted in a clean 5-gallon bucket that was decontaminated prior to collection of each gross sample.

A field duplicate was collected for sample R-RR1-4 and submitted for laboratory analysis (rate of 1 out of every 20 samples). Sample R-RR2-11 was designated the MS/MSD.

B. Nature and Extent of Contamination

As discussed below, the data generated in Phase 1 of the RI were compared with relevant Screening Levels to confirm/refine the PCOCs and PAOCs initially identified in the PSE Report. The results of this preliminary screening step were presented in the Phase 1 Technical Memorandum and are reiterated below and in Section V. A list of Constituents of Potential Concern (COPCs) was developed in Tier 1 of the Human Health Risk Assessment (HHRA) and presented in Chapter VI of this report. The list of COPCs presented in the HHRA was selected

based on standard human health risk assessment methods and all PCOCs identified during the investigative stages of the RI (i.e., PCOCs listed in Section V) were considered in the COPC identification process in the HHRA. Additional relevant screening levels were used in the Tier 1 screening step in both risk assessments.

1. Soil Investigation

The analytical results for the soil samples are summarized in Tables III-4 through III-7. As applicable or relevant and appropriate requirements (ARARs) have not been established, in accordance with USEPA RI FS guidance, the data were compared with Screening Levels to confirm/refine the PCOCs and PAOCs identified based on review of historical Site data during completion of the PSE. For the purpose of this evaluation, the Illinois Tiered Approach to Corrective Action Objectives (TACO) Tier I Soil Remediation Objectives (SROs) for commercial industrial use were used as conservative Screening Levels.¹² The Screening Levels are listed in Tables III-4 through III-7. The Phase 1 laboratory data and data validation reports are submitted under separate cover.

Eleven (11) of the 26 soil samples contained metals concentrations above the Screening Levels. The concentrations of the metals detected above the Screening Levels, which included arsenic, cadmium and zinc, are shown on Figure III-4. The exceedances of Screening Levels occurred at isolated locations within Area 1, Area 2, Area 3 and the Western Area. Zinc was detected above the Screening Level in only one sample (A1-6). The zinc concentration in this sample, 11,000 mg/kg, exceeded the Screening Level of 7,000 mg/kg, which is based on soil leaching to ground water. No VOCs, SVOCs or PCBs were detected in any of the soil samples at concentrations exceeding the respective Screening Levels.

The Screening Level for arsenic was slightly exceeded in three samples: A2-7, A2-19, and A3-19. The Screening Level that was exceeded at these three soil boring locations (11.3 mg/kg) represents average background conditions in non-metropolitan statistical areas (MSAs) of Illinois. Since the detected arsenic levels (12 mg/kg and 13 mg/kg) are very close to the non-MSA background value, which is the Screening Level for both residential and industrial/commercial land use, chemicals containing arsenic are not known to have been used at the Site, and arsenic was not detected in the leachate analyses of the residue piles (see discussion below), arsenic was not identified as a PAOC in soil.

Cadmium was detected above its Screening Level of 11 mg/kg in nine samples, with concentrations ranging from 17 mg/kg to 87 mg/kg. Similar to zinc, the Screening Level for cadmium of 11 mg/kg is based on soil leaching to ground water.

¹² The more conservative of the SROs for the ingestion inhalation and soil-to-ground water pathways were used as the Screening Levels in the comparisons. The Screening Levels used for comparison, for those chemicals that exceeded a Screening Level, are shown on Figure IV-3.

The XRF field screening data presented in Appendix III-2 were used to further evaluate the spatial distribution of cadmium in soils. Because elevated XRF instrument detection limits prevented direct estimation of cadmium concentrations in many of the screening samples, the zinc/cadmium ratio from laboratory samples in which both metals were detected was used to estimate the cadmium concentrations at each screening location where direct estimation using XRF was not possible. The linear relationship between zinc and cadmium, which is plotted in Appendix III-3, indicates that a zinc concentration of 1,653 mg/kg would correspond to a cadmium concentration equal to the Screening Level of 11 mg/kg (for leaching of soil to ground water). Using the statistical "kriging" function provided by Environmental Visualization Software™ (EVS), the extent of zinc concentrations above this threshold are mapped out in Figure III-5.¹³ On Figure III-6, these areas are presented as an overlay on a map containing the soil boring locations and laboratory results exceeding the Screening Levels. As shown, the areas of Screening Level exceedances measured at the laboratory generally fall within the areas of cadmium exceedances predicted using EVS.

Based on these results, cadmium and zinc were designated as PCOCs for soil. As shown on Figure III-6, the soil PAOCs were defined as those portions of Areas 1-4 and the Western Area that were characterized by soil samples exhibiting measured (laboratory quantified) and predicted (estimated from XRF data) concentrations of cadmium and zinc exceeding the Screening Levels. Actual ground water impacts were measured during Phase 2 of the RI and are described in Section IV.

2. Sediment Investigation

The analytical results for the sediment samples are summarized in Tables III-8 through III-11. Similar to soils, TACO SROs were designated as Screening Levels for the purpose of confirming/refining PCOCs and PAOCs for sediment. Screening Levels corresponding to residential land use were used. Seven (7) of the 16 sediment samples collected for laboratory analysis contained one or more metal(s) above the Screening Levels. No VOC, SVOC, or PCB concentrations were detected in sediments above the respective Screening Levels in the Phase I investigation. Vinyl chloride was detected in sediment sample SD-WD-9D at a concentration of 13 ug/Kg, which slightly exceeds its Screening Level of 10 ug/Kg based on soil leaching to ground water. However, a duplicate sample collected at this location had a vinyl chloride concentration of 2.5 ug/Kg, which is below the Screening Level. In the eastern drainageway, zinc and cadmium were detected above the Screening Levels: zinc in sample SD-ED-16 at a concentration of 8,400 mg/kg; and zinc and cadmium in sample SD-ED-13 at concentrations of 11,000 mg/kg and 13 mg/kg, respectively. Only the highly conservative

¹³ Kriging estimates constrained to sample areas.

Screening Levels corresponding to leaching of soil to ground water (7,500 mg/kg for zinc and 11 mg/kg for cadmium) were exceeded in these samples.

In the western drainageway, arsenic, antimony, cadmium, lead and zinc were detected above Screening Levels. Arsenic exceeded the Screening Level based on soil leaching to ground water of 11.3 mg/kg in samples SD-WD-7 and SD-WD-10.¹⁴ Antimony exceeded the Screening Level based on soil leaching to ground water of 5 mg/kg, which is in sample SD-WD-7. Cadmium exceeded the Screening Level based on soil leaching to ground water of 11 mg/kg in samples SD-WD-6, SD-WD-7, SD-WD-8, and SD-WD-9, and the Screening Level based on inhalation/ingestion (78 mg/kg) in samples SD-WD-7 and SD-WD-9. Lead exceeded the Screening Level based on inhalation/ingestion (400 mg/kg) in samples SD-WD-7 and SD-WD-8. Zinc exceeded the Screening Level based on soil leaching to ground water in samples SD-WD-6, SD-WD-7, and SD-WD-8 and SD-WD-9.

In summary, cadmium and zinc were designated as PCOCs for sediment in the eastern drainageway, and antimony, arsenic, cadmium, lead, and zinc were designated as PCOCs for sediment in the western drainageway. Based on these results, the portions of the eastern and western drainageways highlighted on Figure III-7 were designated as PAOCs for sediments.

3. Residue Pile Investigation

The analytical results for the residue pile samples are summarized in Table III-12. Typically, detected SPLP results were one to three orders of magnitude less than detected TCLP results, or had "non-detect" results, reflecting the mildly acidic solution used for the SPLP extraction. Three of the 15 piles/groups of piles, (RR1-3, RR2-11 and MP1-1) had a TCLP lead concentration in excess of 5.0 mg/L. Pile RR1-3 had a TCLP lead concentration of 14 mg/L (SPLP lead of <0.01 mg/L); pile RR2-11 had a TCLP lead concentration of 6 mg/L (SPLP lead of <0.01 mg/L); and pile MP1-21 had a TCLP lead concentration of 83 mg/L (SPLP lead of 0.62 mg/L). The TCLP lead results above the RCRA hazardous waste threshold of 5.0 mg/L are depicted on Figure III-8. No other metals had TCLP results in excess of their respective RCRA hazardous waste threshold values.¹⁵

Based on these results, TCLP lead was identified as a PCOC for the residues and the piles designated RR1-3, RR2-11 and MP1-21 were identified as PAOCs for residues. As discussed in Section IV.A.4, additional sampling of these residue piles was conducted during the Phase 2 investigation to provide additional characterization.

¹⁴ As discussed for soil, the Screening Level represents average soil background conditions in non-MSAs of Illinois. Sample SD-WD-10 was collected in a drainage sample and is not believed to have been impacted by the site based on low detected concentrations of zinc.

¹⁵ The residue piles with TCLP lead results above the RCRA threshold are not necessarily hazardous waste.

IV. PHASE 2 – MIGRATION PATHWAY ASSESSMENT

A. Study Area Investigations

The Phase 2 field activities were conducted at the Site between March 10, 2003 and March 19, 2003. In addition, ground water and surface water sampling activities were conducted between June 19, 2003 and June 23, 2003 and on November 24, 2003. All field activities were conducted and/or supervised by ENVIRON. All piezometer installation, monitoring well installation, temporary well installation, well development, and residue pile test excavation activities were conducted by Philip Services, Inc. (Philip). All laboratory analyses were conducted by EnChem. Site surveying work was conducted by Hurst-Rosche Engineers. Tables IV-1 through IV-4 provide a summary of all investigative samples collected as part of Phase 2 of the RI.

1. Site Surveying

As discussed below, Hurst-Rosche surveyed the locations and elevations of the piezometers, monitoring wells, temporary monitoring wells, and a staff gage installed in the southwest pond. Based on field conditions (e.g., marshy conditions, steep terrain, etc.), some piezometer and monitoring well locations were adjusted from the proposed locations the minimum distance necessary to allow drill rig access.

2. Ground Water Investigation

In accordance with the RI/FS Work Plan and certain augmentations to the Phase 2 program proposed in the Phase 1 Technical Memorandum and approved by the USEPA, the scope of the ground water investigation included:

- Installation of six (6) permanent piezometers and four (4) temporary piezometers, with ground water elevations determined as discussed in the RI/FS Work Plan. All piezometers were installed between March 10, 2003 and March 12, 2003.
- Installation of eleven (11) additional permanent monitoring wells. Monitoring wells MW1 through MW10 were installed between March 12, 2003 and March 15, 2003. Monitoring well MW11 was installed on June 19, 2003.
- Installation of three (3) temporary monitoring wells on off-Site properties, not owned by Eagle Zinc Company, located west of the southwest portion of the Site. These temporary wells were installed on June 19 and 20, 2003.
- Sampling of the newly installed and existing monitoring wells and off-Site temporary monitoring wells as discussed in the RI/FS Work Plan. With the exception of MW11, which was installed in June 2003, all on-Site permanent

monitoring wells were sampled on March 18, 2003 and March 19, 2003. The three off-Site temporary monitoring wells and MW11 were sampled on June 20, 2003.

- Installation and surveying of a staff gauge in the southwest pond to determine the elevation of the pond surface water relative to ground water. The staff gauge was installed on March 10, 2003.
- Collection of four additional surface water samples and two additional sediment samples in the western drainageway up gradient of the southwest pond, and one an additional ground water sample from MW11. These samples were collected on November 24, 2003 and the analytical parameters included TCL VOCs. The results of this additional sampling phase were reported in the monthly progress report dated January 9, 2004 submitted to USEPA.

a. Piezometer Installation

Six (6) permanent and four (4) temporary piezometers were installed at the Site to provide a preliminary confirmation of the pattern of ground water flow and to confirm locations for additional permanent monitoring wells. The surveyed locations of the piezometers are shown on Figure IV-1. The piezometers were designated P1 through P10, with the permanent piezometers numbered P1 through P6 and the temporary piezometers numbered P7 through P10. All of the piezometers were installed using a truck-mounted direct-push drilling apparatus (i.e., Geoprobe). Two-inch outside diameter macro-core soil samples were collected continuously to an appropriate depth below the top of the saturated zone and soil boring logs were prepared by an ENVIRON geologist. All soil cores were screened for organic vapors at 6-inch intervals using a PID. To construct each piezometer, a one-inch diameter section of PVC screen and riser pipe was placed in the core hole and a clean sand filter pack was placed around the PVC, generally to a depth of one to two feet above the top of the screen. The screen was placed so as to straddle the water table. A seal of granular bentonite was then placed in the annular space above the sand pack. The permanent piezometers were completed with stick-up type protective casings with locking caps. The temporary piezometers were completed with non-locking PVC caps. Piezometer drilling and construction logs are provided in Appendix IV-1.

Water level measurements were collected from all piezometers, as well as pre-existing monitoring wells G101 through G109 and converted to water level elevations using surveyed benchmarks at the top of the piezometer casings. Preliminary ground water elevations determined from the piezometers and pre-existing monitoring wells confirmed that the locations selected for the additional monitoring wells were

appropriate for monitoring ground water quality downgradient of potential areas of concern for soils identified during the Phase 1 investigation.

Following the complete round of synoptic water level measurement conducted in March 2003 immediately prior to ground water sampling, the four temporary piezometers (P7 through P10) were abandoned by removing the PVC, returning the soil cores to the borehole, and sealing the remainder of the borehole with granular bentonite.

b. Monitoring Well Installation

Eleven (11) monitoring wells (MW1 through MW11) were installed at the Site using the hollow-stem auger drilling method. The surveyed locations of the monitoring wells are shown on Figure IV-1. The following adjustments were made to the array of Site monitoring wells in the field:

- At the onset of the Phase 2 fieldwork, pre-existing monitoring well G108 was found to have been damaged and partially filled with rocks. This well was properly abandoned by Philip by removing the entire well, including the screen and riser, and sealing the remaining hole with bentonite.
- The location of the proposed monitoring well proposed in the Phase 1 Technical Memorandum in the southwest corner of the Site was inaccessible, as the location depicted on this figure was within the steep ravine located between the southwest pond embankment and higher ground to the south of the Site. Therefore, this monitoring well (MW8) was installed on the pond embankment itself, as close as feasible to the proposed location (approximately 60 feet north of the proposed location). The selected location for MW8 is directly downgradient of the southwest pond and upper portions of the Western Drainageway. As MW8 was installed close to G108 and serves equally as a downgradient monitoring point, well G108 was not replaced with a new monitoring well.
- The location initially proposed for a new monitoring well near the on-Site drainageway leading into the pond at the southwest corner of the Site was inaccessible in both March 2003 and June 2003, as a broad area of standing water covered the proposed location. Therefore, this monitoring well (MW11) was installed in June 2003 at the closest accessible location, which was approximately 200 feet east of the proposed location.

Split-spoon samples were collected at five-foot intervals from the ground surface to the completion depth of the monitoring well and the samples were logged by the

ENVIRON geologist.¹⁶ Following the completion of a 6-inch diameter borehole, 2-inch inside diameter sections of schedule-40 PVC screen and riser pipe were placed in the borehole and a clean sand filter pack was placed around the screened interval. The well screen was installed such that it straddled the water table. A bentonite seal was then placed in the well annulus and the monitoring well was completed with a stick-up type protective casing with a locking cap. Drilling and well construction logs for the monitoring wells are presented in Appendix IV-1.

Each newly installed monitoring well was developed no sooner than 12 hours following well installation. In addition, to ensure adequate flow of ground water into the wells, pre-existing wells G101 through G109 were redeveloped. Well development consisted of the removal of a minimum of three times the measured casing volume of water plus three times the saturated volume of the monitoring well sand pack using dedicated polyethylene bailers. Well development was *deemed complete when this volumetric criterion and a reasonably clear discharge was achieved.*¹⁷

c. Temporary Monitoring Well Installation

As proposed in ENVIRON's May 30, 2003 letter to the USEPA and approved by the USEPA in a letter dated June 9, 2003, three (3) temporary monitoring wells were installed on off-Site properties on June 19 and 20, 2003 to provide supplementary ground water data in the area west of the southwest portion of the Site.

The temporary wells were designated TW5 through TW7 and were installed using a truck-mounted direct-push drilling apparatus (i.e., Geoprobe). Two-inch outside diameter macro-core soil samples were collected continuously to an appropriate depth below the top of the saturated zone and soil boring logs were prepared by an ENVIRON geologist. All soil cores were screened for organic vapors at 6-inch intervals using a PID. To construct each temporary well, a one-inch diameter section of PVC screen and riser pipe was placed in the core hole and a clean sand filter pack was placed around the PVC, generally to a depth of one to two feet above the top of the screen. The screen was placed so as to straddle the water table. A seal of granular bentonite was then placed in the annular space above the sand pack. The temporary wells were completed with non-locking PVC caps. Drilling and construction logs for the temporary wells are provided in Appendix IV-1. The temporary wells were developed using the procedures described above for the permanent monitoring wells. Field parameters were not measured during development of the temporary wells.

¹⁶ Prior to installation with the hollow-stem auger drilling rig, soils at monitoring wells MW01 and MW02 were first logged using a Geoprobe drilling apparatus (i.e., by collecting 4-foot long macro-core samplers)

¹⁷ While noted in the RI/FS Work Plan, field parameters were not measured during well development.

Following surveying and a complete round of synoptic water level measurement conducted on June 23, 2003, the temporary wells were abandoned by removing the PVC, returning the soil cores to the borehole, and sealing the remainder of the borehole with granular bentonite.

d. Water Level Measurement

On March 17, 2003, prior to initiation of ground water sampling, an electronic water level meter was used to measure the depth to ground water in each monitoring well and piezometer. The measurements were made to the nearest one hundredth (0.01) of a foot relative to a surveyed and marked location at the top of the well casing. In addition, the elevation of the southwest pond was determined using a surveyed staff gage. The calculated piezometer, monitoring well, staff gage, and water level elevations are summarized in Table IV-5. The piezometric data were used to construct a Site-wide ground water contour map. A second complete set of water level measurements was made on June 23, 2003, which included MW11 and the off-Site temporary wells. These data are also presented in Table IV-5. Shallow ground water contour maps for the two measurement dates are presented as Figures IV-4 and IV-5, respectively.

e. Ground Water Sampling

Following the completion and development of the newly installed permanent and temporary monitoring wells, all pre-existing and newly installed wells were sampled for TAL metals and sulfate (with the exception of sulfate from MW11).¹⁸ In addition, four of the ground water samples (MW1, MW4, MW8, and G107) were analyzed for TCL organic compounds and PCBs. The metals analyses were conducted using both field-filtered and unfiltered samples to determine dissolved and total metals concentrations, respectively.

For the ground water sampling program conducted in March 2003, field duplicate samples were collected at locations where the full list of analyses (i.e., TAL Metals, sulfate, and TCL Organics) were performed and submitted to the laboratory for analysis of the same parameters at a rate of 1 out of 20.¹⁹ A minimum of 1 out of 20 samples were designated as a MS/MSD sample. Based on the number of ground water samples

¹⁸ As proposed in ENVIRON's May 30, 2003 letter to USEPA, MW11 was sampled for TAL Metals only. In addition, monitoring wells MW-A, MW-B, MW-D and MW-E, which were installed and sampled pursuant to a UST compliance program under the oversight of IEPA, were not sampled. As proposed in ENVIRON's May 30, 2003 letter to USEPA, the three off-Site temporary wells were sampled for TAL Metals (dissolved and total). Additionally, monitoring well G-108 was found to be damaged and was subsequently abandoned.

¹⁹ The field duplicate sample for the VOC fraction of TCL Organics was inadvertently not analyzed by the laboratory. However, as discussed in Section IV.A.2.c, no VOCs were detected in any of the ground water samples.

(19), during the ground water sampling program conducted in March 2003, one field duplicate sample was collected at MW1 and one MS/MSD was collected at MW1.

All three temporary wells and on-Site monitoring well MW11 were sampled on June 20, 2003. The sample collected from MW11 was designated as the MS/MSD and a field duplicate sample was collected from MW11.

A peristaltic pump was used to purge and sample all permanent and temporary monitoring wells. During well purging, measurements for field parameters (pH, specific conductance, temperature, and dissolved oxygen) were made. While purging, field parameters were monitored continuously using a flow-through sampling cell. Monitoring well purging was considered complete when a minimum of three times the measured casing volume had been removed, and the field-measured parameters of pH, specific conductance, and temperature had stabilized. Monitoring wells G-101, G-105, G-107, MW8, MW9 and MW10 and temporary wells TW5 and TW7 pumped dry before the volumetric criterion was reached. Following one or more pumping episodes in which these wells went dry, these wells were sampled once a sufficient amount of water had recharged in the well. Only wells G-107, TW5 and TW7 did not meet the volumetric purge criteria. Monitoring well sampling details are included in Appendix IV-2.

Filtered and unfiltered ground water samples were collected for the TAL Metals analyses. Field filtering was conducted using dedicated 0.45-micron filters.

3. Surface Water Investigation

As described in the RIFS Work Plan, each surface water sample was co-located with a Phase 1 sediment sample that was either: (1) located on, or downstream of the Site and exhibited elevated metals concentrations; or (2) represented an upstream location not expected to have been impacted by Site operations. Surface water samples were collected in both of the Site's two major surface water drainageways (i.e., upstream and downstream of storm water Outfalls 1 and 2²⁰). As proposed in the Phase 1 Technical Memorandum, in March 2003, surface water samples were collected at a total of ten (10) locations: three (3) within the eastern drainageway; and seven (7) within the western drainageway (includes two samples from the southwest pond). Surface water samples were collected in both drainageways on March 10, 2003 and March 19, 2003. As proposed in ENVIRON's May 30, 2003 letter to USEPA and approved by USEPA in a letter dated June 9, 2003, three additional surface water samples were collected in the Western Drainageway on June 13, 2003.

²⁰ Outfall designations associated with the Site's NPDES storm water discharge permit (Permit No. IL0074519), which was terminated by IEPA on July 10, 2003 in response to the cessation of operations at the site.

On both sampling dates, sufficient surface water was present at each proposed location to allow for the collection of a surface water sample. The surface water samples were collected as grab samples by submerging the sample container with the open end facing upstream. For samples containing a preservative or fixing agent, the samples were collected using a laboratory-cleaned glass sample jar and immediately transferred to the proper sample container. Sample collection was performed in such a way that disturbance of bottom sediments was minimized during sample collection. In both drainageways, the sampling activities proceeded from downstream to upstream so that any disturbed sediment did not impact subsequent sampling.

All surface water samples collected in March 2003 were analyzed for TAL metals and sulfate. In addition, as shown on Figure IV-2, six (6) of the samples (SW-WD-7, SW-WD-9, SW-WD-10, SW-WD-PN, SW-ED-11, and SW-ED-13) were analyzed for TCL organic compounds and PCBs. Field duplicate samples were collected at locations where the full list of analyses were performed and submitted for laboratory analysis of the same parameters at a rate of 1 out of 20. A minimum of 1 out of 20 samples were designated as a MS/MSD sample. Based on the number of surface water samples (10), one field duplicate sample was collected at SW-WD-7 and one MS/MSD was collected at SW-WD-9.²¹

The three additional surface water samples collected on June 13, 2003 (SW-WD-6-061303, SW-WD-11, and SW-WD-12) were analyzed for TAL metals. The sample collected on this date at SW-WD-6 was designated the MS/MSD and a field duplicate was collected at this location. The additional surface water samples were approved by USEPA a letter dated June 9, 2003.

4. Supplementary Residue Sampling

During Phase 1 of the RI, three of the 15 residue piles/groups of piles (RR1-3, RR2-11 and MP1-21) had a TCLP lead concentration that exceeded the RCRA hazardous waste threshold of 5.0 mg/L. As proposed in the Phase 1 Technical Memorandum, these residue piles/pile groups were further characterized by subdividing each pile/group into imaginary sections and collecting one gross composite sample from each section for laboratory analysis of TCLP lead. The purpose of the supplementary sampling was to better define sections of the piles that exceed the TCLP RCRA hazardous waste threshold value for lead of 5.0 mg/L. The locations of the residue piles sampled and the pile sections represented by the composite samples are shown on Figure IV-3.

Based on volumetric estimates and pile layout, each pile was divided into a number of equal sections. Eight (8) samples were collected from pile RR2-11, two (2) samples were

²¹ The MSD sample for PCBs analysis was not analyzed as the bottle broke during shipment to the laboratory. However, no PCBs were detected in any of the surface water samples.

collected from pile RR1-3, and three (3) samples were collected from the MP1-21 piles. Each sample was collected as a composite of three sample increments, and was collected either as depth composites or area composites.²² The sample compositing methodology was as discussed in the RI/FS Work Plan.

Each composite sample was analyzed for lead using the TCLP. A field duplicate was collected for sample R-RR1-3-S1D (rate of 1 out of every 20 samples). Sample R-MP1-21-S3 was designated the MS MSD.

5. Soil pH Sampling

To determine the general range of Site-wide soil pH conditions, one soil sample was collected for laboratory soil pH analysis from each of the 20 soil borings completed for installation of the monitoring wells and piezometers. The majority of the soil pH samples were collected one foot below the depth at which undisturbed native soil was encountered.²³

6. VOC Sampling in Western Drainageway and MW11

On November 24, 2003, additional surface water and sediment samples were collected from the on-Site portion of the Western Drainageway and an additional ground water sample was collected from monitoring well MW11. Specifically, four surface water samples were collected: at previous surface water sampling locations SW-WD-PN (Pond North) and SW-WD-09; at a location 100 feet upstream of SW-WD-09; and at a location 200 feet upstream of SW-WD-09. Two additional sediment samples were collected which were co-located with the surface water samples collected 100 and 200 feet upstream of SW-WD-09, respectively. Finally, one ground water sample was collected from MW11.

All samples collected on November 24, 2001 were analyzed for the VOC fraction of the TCL list using the sampling and analytical procedures described above and the in the RI/FS Work Plan. All necessary field and laboratory QA/QC samples were also collected and analyzed.

7. Off-Site Air Deposition

This potential migration pathway was evaluated through the review of off-site surface soil sampling data collected by IEPA prior to the on-set of the RI/FS, local meteorological information, and observations made concerning the characteristics of the residue piles and the

²² Similar to the sampling procedure employed during the Phase I residue sampling program, the depth composites were collected at three equally spaced depths within the pile by completing test trenches. Area composites, consisting of sample increments spaced evenly across the section to be sampled, were collected for lower, horizontally extensive piles.

²³ At several locations, a slightly deeper interval was selected for collection of the pH sample, as the pH samples were collected from split-spoon samples that, in accordance with the RI/FS Work Plan, were taken from the monitoring well boreholes at 5-foot intervals. However, all pH samples are believed to be representative of the uppermost native soils encountered in the borings, which ranged in texture from silty clay to silty sand.

potential for entrainment of particulate material from the piles. The results of this review are discussed in Section IV.B.6.below.

B. Nature and Extent of Contamination

As discussed below, the data generated in Phase 2 of the RI were compared with relevant Screening Levels to confirm/refine the PCOCs and PAOCs initially identified in the PSE Report. The results of this preliminary screening step were presented in the Phase 2 Technical Memorandum and are reiterated below and in Section V. A list of Constituents of Potential Concern (COPCs) was developed in Tier 1 of the Human Health Risk Assessment (HHRA) and presented in Chapter VI of this report. The list of COPCs presented in the HHRA was selected based on standard human health risk assessment methods and all PCOCs identified during the investigative stages of the RI (i.e., PCOCs listed in Section V) were considered in the COPC identification process in the HHRA. Additional relevant screening levels were used in the Tier 1 screening step in both risk assessments.

1. Ground Water Investigation

a. Ground Water Flow

Using ground water levels measured in the monitoring wells and piezometers on March 17, 2003, a ground water contour map (Figure IV-4) was constructed, which shows the inferred pattern of shallow ground water flow across the Site. The shallow ground water flow pattern is consistent with the previous interpretation presented on Figure II-3 of the RI/FS Work Plan, in that it shows an inferred southward/southwestward ground water flow direction in the western and southwestern portions of the Site and an eastward/southeastward flow direction in eastern portions of the Site. These flow regimes are separated by a roughly north-south trending ground water divide. Based on the existence of the divide, ground water in the northwestern most portion of the Site may locally exhibit a northward or northwestward flow component. However, based on the local topography, most if not all of the Site's ground water is believed to ultimately flow either southwestward (towards and parallel with the Western Drainageway) or eastward/southeastward (towards and parallel with the Eastern Drainageway). In all areas of the Site, the shallow ground water flow pattern generally reflects the surface topography.

A second ground water contour map was constructed using water level elevation data collected on June 23, 2003 and is included as Figure IV-5. Water level elevations determined from the temporary off-site monitoring wells were used to estimate the shallow ground water flow pattern in the area immediately west of the southwest portion

of the Site. This contour map exhibits an inferred ground water flow pattern similar to that depicted on Figure IV-4, with westward flow of ground water continuing in the area west of the southwest portion of the Site.

b. Ground Water Analytical Results

The analytical results for the ground water samples are summarized in Tables IV-6A through IV-6D. Since ARARs have not been established, in accordance with USEPA RI/FS guidance, the data were compared with conservative Screening Levels to confirm/refine the PAOCs identified based on review of historical Site data during completion of the PSE. For the purpose of this evaluation, the Illinois TACO ground water remediation objectives were used as Screening Levels.²⁴ The Screening Levels are listed in Tables IV-6A through IV-6D. Ground water constituent concentrations that exceed the Screening Levels are summarized on Figure IV-6. The Phase 2 laboratory data and data validation reports are submitted under separate cover.

Metals

As shown on Figure IV-6, no total or dissolved metals concentrations exceeded the Screening Levels in monitoring wells G101, G103, G105, G106 and MW2, and only manganese exceeded the Screening Levels in wells G102 and MW5.²⁵ A low concentration of total thallium exceeding the Screening Level was detected in MW1; however, thallium was not detected in a duplicate sample collected concurrently from MW1. Concentrations of a broader list of metals exceeded Screening Levels in dissolved and or total metals samples in wells located in the southwest portion of the Site and in the temporary monitoring wells located west of the southwest portion of the Site.

Sulfate

Sulfate concentrations exceeded the Screening Level of 400 mg/L in six of the monitoring wells: G107 (920 mg/L); MW1 (530 mg/L); MW3 (730 mg/L); MW6 (900 mg/L); MW7 (720 mg/L); and MW9 (1,700 mg/L).

²⁴ The Illinois TACO ground water remediation objectives for both Class I and Class II ground water (35 IAC 742; Appendix B, Table 1) are presented for screening purposes, with concentrations exceeding the more stringent standards (Class I) shown in bold type.

²⁵ It is noted that the manganese concentrations detected in upgradient wells G102 and MW5 likely represent natural background conditions in the ground water.

VOCs and SVOCs

No VOCs were detected in any of the ground water samples. With only one exception, no SVOCs were detected in any of the ground water samples. The SVOC caprolactam was detected in G107 at an estimated concentration of 0.00295 mg/L and in MW4 at a concentration of 0.1 mg/L. According to USEPA's Integrated Risk Information System (IRIS), caprolactam is used in the manufacture of synthetic fibers, especially nylon, and is therefore not believed to have been used on-site for the historical manufacture/ processing of zinc/zinc compounds or for any other purpose. Caprolactam does not have an Illinois TACO ground water remediation objective. However, as the USEPA Region 9 Preliminary Remediation Goal (PRG) for this compound in "tap water" is 18 mg/L, its occurrence at the Site does not appear to pose an unacceptable risk; this compound therefore has not been designated as a PCOC for ground water.

PCBs

No PCBs were detected in any of the ground water samples.

c. Discussion

Based on the ground water sampling results for dissolved metals samples, zinc, cadmium, iron, lead, manganese and thallium were designated as PCOCs for ground water. The highest dissolved metals concentrations in ground water were detected in MW7. MW7 was installed at a location immediately downgradient (west) of a AOC for soils, which is depicted on Figure III-6 of this report. Sulfate was also identified as a PCOC.

As shown on Figure IV-6, an area including the southwestern portion of the Site and a small off-Site area south and west of the western Site boundary (wooded area on an industrial property) is designated as a PAOC for ground water.²⁶

2. Surface Water Investigation

a. Surface Water Analytical Results

The analytical results for the surface water samples are summarized in Tables IV-7A through IV-7D. Again, since ARARs have not been established, in accordance with USEPA RI/FS guidance, the data were compared with conservative Screening Levels to confirm/refine the PAOCs identified based on review of historical

²⁶ The non-toxic inorganic constituents iron, manganese and sulfate were not considered in the estimation of the ground water PAOC.

Site data during completion of the PSE. For the purpose of this evaluation, the Illinois Water Quality Standards: 35 IAC 302 Subpart B (General Water Quality Standards), and 35 IAC 302 Subpart D (Secondary Contact and Indigenous Aquatic Life Standards) were used as Screening Levels. National Recommended Water Quality Criteria were used as Screening Levels for those constituents that do not have Illinois Water Quality Standards. The Screening Levels are listed in Tables IV-7A through IV-7D. The Phase 2 laboratory data and data validation reports are submitted under separate cover. Surface water constituent concentrations that exceed the Screening Levels are summarized on Figure IV-7.

Metals

With the exception of sample SW-ED-16, collected in the Eastern Drainageway near Lake Hillsboro, and samples SW-WD-11 and SW-WD-12 collected in the Western Drainageway, each surface water sample collected in both drainageways contained zinc concentrations that exceeded the Screening Level of 1 mg/L (ranged from 1.2 mg/L and 26 mg/L).²⁷ In addition, samples SW-WD-PS, SW-WD-PN, and SW-WD-9 contained cadmium concentrations that exceed the Screening Level of 0.05 mg/L (ranged from 0.069 mg/L to 0.23 mg/L). Finally, samples SW-WD-8 and SW-WD-10 contained iron concentrations that exceeded the Screening Level of 2 mg/L (3.2 mg/L and 15 mg/L, respectively).

Sulfate

None of the sulfate concentrations detected in the surface water samples exceeded the Screening Level of 500 mg/L. Sulfate concentrations ranged from 21 mg/L to 450 mg/L, with the highest concentrations detected in the Western Drainageway.

VOCs and SVOCs

No SVOCs were detected in any of the surface water samples. No VOCs were detected at concentrations exceeding their respective screening levels. The VOC cis-1,2-dichloroethene was detected in surface water samples SW-WD-9 and SW-WD-PN at concentrations of 0.002 mg/L and 0.022 mg/L, respectively. The VOC trichloroethene (TCE) was also detected in these two surface water samples at concentrations of 0.0063 mg/L and 0.0014 mg/L, respectively.

²⁷ It is noted that the zinc concentration detected at SW-ED-11 (1.2 mg/L) likely represents background surface water conditions in the Eastern Drainageway. The Eastern Drainageway originates at or near this offsite location, which exclusively receives runoff from a sports playing field located north of the Site (i.e., no surface water drainage from the Site occurs to this portion of the Drainageway).

PCBs

No PCBs were detected in any of the surface water samples.

b. Discussion

Based on these results, cadmium, iron and zinc were identified as PCOCs for surface water in the Western Drainageway. Only zinc was identified as a PCOC for surface water in the Eastern Drainageway. With the exception of a portion of the Eastern Drainageway proximal to Lake Hillsboro, portions of both drainageways immediately downstream of the Site are considered PAOCs for surface water.

3. Supplementary Residue Sampling

The analytical results for the residue pile samples are summarized in Table IV-8. With the exception of one composite sample collected from residue Pile RR2-11, each composite sample had a TCLP lead concentration in excess of the RCRA hazardous waste threshold of 5.0 mg/L.²⁸ The TCLP lead concentrations in Pile RR2-11 ranged from 2.2 mg/L to 18 mg/L. The TCLP lead concentrations in Pile RR1-3 ranged from 23 mg/L to 28 mg/L. The TCLP lead concentrations in Pile MP1-21 ranged from 18 mg/L to 230 mg/L.

Based on these results, TCLP lead continues to be considered a PCOC for the residues, and the piles designated RR1-3, RR2-11 and MP1-21 continue to be designated as PAOCs for residues.

4. pH Soil Sampling

The pH soil sampling results are summarized in Table IV-9. The soil pH values ranged from 4.3 to 7.9 Standard Units.

5. VOC Sampling in Western Drainageway and MW11

The analytical results for the supplementary VOC samples collected from the Western Drainageway and MW11 on November 24, 2003 are summarized in Table IV-10 (surface water), Table IV-11 (sediment) and Table IV-12 (ground water). In addition, detected constituent concentrations are summarized on Figure IV-8 (surface water and ground water) and Figure IV-9 (sediment). While low levels of the VOCs cis-1,2-dichloroethene and TCE were detected in all of the surface water and sediment samples, none of the detected concentrations exceeded the respective Screening Levels. No VOC concentrations were detected in the ground water sample collected from MW11.

²⁸ 40 CFR 262.11.

6. Off-Site Particle Deposition

Three lines of evidence indicate that deposition of airborne particles from the Site has not impacted off-site areas. First, literature concerning dust emissions from aggregate piles indicates that extensive off-site windborne dust migration would not be expected. For example, Section 13.2.5.1 of the USEPA's January 1995 Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume I: *Stationary Point and Area Sources* states, 'Field testing of coal piles and other exposed materials using a portable wind tunnel has shown that (a) threshold wind speeds exceed 5 meters per second (m/s) (11 miles per hour [mph]) at 15 cm above the surface or 10 m/s (22 mph) at 7 m above the surface, and (b) particulate emission rates tend to decay rapidly (half-life of a few minutes) during an erosion event. In other words, these aggregate material surfaces are characterized by finite availability of erodible material (mass/area) referred to as the erosion potential. Any natural crusting of the surface binds the erodible material thereby reducing the erosion potential.' Therefore, any air erosion of the piles would be expected to be temporally limited to a very short period immediately following emplacement.

Second, as discussed above, the prevailing wind direction is from the south and south-southwest. As a result, any impact to soil would be expected to be greatest in the area immediately north or north-northeast of the areas used for residue storage. Therefore, the fact that no on-site soil impacts in the Northern Area of investigation were identified in the Phase I investigation demonstrates the lack of significance of this potential transport pathway even in close proximity to potential sources.

A series of well-distributed soil samples were collected at residential properties in the vicinity of the Site by IEPA in 1993. Figure IV-10 shows the IEPA off-site residential soil samples and RI/FS laboratory-analyzed on-site soil samples taken in the Northern Area, concentrations of the metals in these samples that were identified as PCOCs in the investigation phases of the RI, and a superimposed wind-rose diagram. As shown on Figure IV-10, metals concentrations generally decrease with distance from the Site. Moreover, with the exception of arsenic, vanadium, and manganese, all metals concentrations in the IEPA soil samples were below conservative USEPA screening levels for residential soils (USEPA Region 3 RBCs). As discussed in Section VI.B.3 of the RI Report, the arsenic concentrations detected above the USEPA Region 3 RBC of 11.2 mg/kg (11.9, 13.4, and 13.6 mg/kg, respectively) were only marginally above the average regional background level, as reflected by the non-Metropolitan Statistical Area (MSA) background value presented in the Illinois Tiered Approach to Corrective Action Objectives (11.3 mg/kg). In addition, arsenic is not known to have been used or released at the Site. All of the vanadium concentrations detected in the off-site soil samples were within the range of natural background concentrations for this

metal (10-100 mg/kg) and below the mean background concentration of 62 mg/kg.²⁹ Finally, the RBC for manganese was marginally exceeded, but in only one sample. These findings were memorialized in a letter dated February 22, 1994 from Mr. K.D. Runkle of the Illinois Department of Public Health (IDPH) to Mr. Brad Taylor of IEPA's Site Assessment Unit, which states that the soil data collected by IEPA at off-Site Residences indicate "no apparent health concern." This opinion was also conveyed to the residents whose properties had been sampled.

In summary, the limited wind erosion of aggregate piles expected on the basis of experience at other sites was borne out in the absence of elevated concentrations of site-related constituents both on-site in proximity to potential sources and in off-site soil samples. On these bases, off-site airborne deposition of particulate matter from residue piles is not considered a significant transport pathway at the Eagle Zinc site. However, this issue will be discussed further in the RI Addendum.

²⁹ Dragun, J. and Chiasson, A. 1991. *Elements in North American Soils*. Hazardous Materials Control Resources Institute.

V. SITE CONCEPTUAL MODEL

A. Contaminant Fate and Transport

The following is a generalized discussion of the fate and transport of the constituents identified as PCOCs (tabulated below). Non-toxic species (e.g., iron and sulfate) are excluded from this discussion. While none of the PCOCs discussed below were excluded from the evaluation of site data in the risk assessments, a refined list of Constituents of Potential Concern (COPCs) was developed in Tier 1 of the HHRA, as discussed in Section VI of this report.

Metals

Certain metals were identified as PCOCs in on-site soil, sediments in both drainageways, ground water, and surface water. Predicting the migration of metals in the environment is complicated because metals can exist in a variety of forms. For instance, they may exist as charged particles, such as ions in solution, or in an uncharged or neutral state. Metals may also interact with both inorganic and organic species to form a variety of different compounds of variable solubilities. Multiple oxidation states of some metals further complicate their behavior.

The potential for migration of any form depends upon the solubility of the form in water. Metals in solution exist in an ionic form. These ions may be transported as such, or undergo processes such as adsorption to organic matter or mineral surfaces of sediment, soils, and suspended solids. Nonionic forms tend to precipitate and remain bound to sediments and soil or they may be transported as suspended solids. Metals may cycle between the aqueous and solid phases with limited actual transport from the site area. Metals will often be present as compounds that may have different physical-chemical properties to the metals themselves. Below are general descriptions of the environmental behavior of the metals identified as PCOCs following completion of the investigative phases of the RI.

Aluminum

Aluminum is highly reactive and, in nature, is found in combination with other substances such as oxygen, fluoride, and silica. There is only one oxidation state for aluminum, 3+. Due to its single oxidation state, aluminum is not redox-sensitive. Principal transport processes include leaching from geochemical formations and soil particulates to water, complexation, and adsorption onto soil or sediment particulates. In general, the mobility of aluminum increases as the pH decreases below 5 or increases above 10 for monomeric forms. At low pH, adsorption onto clay and suspended particulates is a significant and rapid

process. Below a pH of 5 the aluminum $3+$ reacts strongly with the negative organic ligands of organic acids.

Antimony

Antimony in the atmosphere is in particulate form and can be adsorbed to particulate matter. Transport to land and surface water occurs through gravitational settling and other forms of dry and wet deposition. The fate of antimony in the environment is complicated because it can exist in four oxidation states, $3-$, 0 , $3+$, and $5+$. In the aquatic environment, antimony is mainly associated with particulate matter and tends to settle out in areas of active sedimentation. Some forms of antimony are strongly sorbed to soil, making it relatively immobile. Antimony may also adsorb strongly to colloidal materials in soil which may become mobilized and transported to ground water. In general, adsorption is greatest at near neutral pHs.

Arsenic

Because of its multiple oxidation states and its tendency to form soluble complexes, the geochemistry of arsenic is both intricate and not well characterized. Arsenic is mobile in the aquatic environment; it cycles through water columns, sediments, and biota. The solubility of arsenic varies widely according to the oxidation state. In the natural environment, four oxidation states are possible for arsenic: $3-$, 0 , $3+$, and $5+$. The adsorption of arsenic onto clays, iron oxides, and humic material are important fate processes. Co-precipitation or sorption of arsenic with hydrous oxides of iron is probably the most important removal process. Arsenic may also be isomorphously substituted for phosphate in phosphate minerals. The rate and extent of adsorption decreases with increasing salinity and increasing pH. Adsorption is highest in aerobic, acidic, and freshwater systems. Arsenic is relatively immobile in soils due to its binding to soil particles, but may be leached under the appropriate conditions. It binds to clay, iron oxides, aluminum hydroxides, and organic matter.

Beryllium

The behavior of beryllium is controlled largely by precipitation, adsorption, and complexation. It exists in the valence state, $2+$. Soluble beryllium salts are hydrolyzed in waters to form insoluble beryllium hydroxide. Adsorption to clay and minerals is important at low pH. Beryllium can form complexes, oxycarboxylates, and chelates with a variety of materials resulting in increased solubility of beryllium species. In natural waters, most of the beryllium is found in particulate form, either sorbed or precipitated.

Cadmium

Complexation, adsorption, co-precipitation, isomorphous substitution, and bioaccumulation are processes which affect the movement of cadmium in the environment. Cadmium exists in one oxidation state, 2+. Compared to the other heavy metals, cadmium is relatively mobile at an approximate pH of less than 5 and greater than 9 and may be transported as either hydrated cations or as organic or inorganic complexes. Cadmium forms complexes with humics, predominately CO_3^{2-} , SO_4^{2-} , and also OH^- and Cl^- . Sorption to mineral surfaces generally increases as the pH increases within the approximate pH range of 5 to 9 and is responsible for removal of cadmium from the aqueous phase. Other processes which serve to remove cadmium from water include adsorption onto organic matter, co-precipitation with hydrous metal oxides and isomorphous substitution in carbonate minerals.

Chromium

Chromium has three oxidation states: 2+, 3+, and 6+. However, in aqueous systems, it exists primarily in two oxidation states, 3+ and 6+. The hexavalent form is the most common form in natural waters. This species is soluble, existing in solution as an anion complex which may eventually precipitate. Hexavalent chromium is a strong oxidizing agent and reacts with organic or other reducing material to form trivalent chromium. Hexavalent chromium (Cr^{6+}) is not absorbed to any significant degree by clays or hydrous metal oxides. It is, however, absorbed strongly to activated carbon, which is an indication that it may be retained by organic matter. Hexavalent chromium is quite mobile in the environment. Trivalent chromium combines with aqueous hydroxide ion (OH^-) to form insoluble chromium hydroxide [$\text{Cr}(\text{OH})_3$]. Precipitation of this material is thought to be the dominant removal process of chromium in natural waters. Adsorption processes also result in removal of dissolved chromium to the bed sediments. Chromium in soil can occur as the insoluble oxide dichromate (Cr_2O_3).

Copper

Copper exists in two oxidation states, 1+ and 2+. The only cuprous (Cu^+) compounds that are stable in aqueous solutions are highly insoluble (i.e., CuCl , CuF , and CuCN). Most of the cupric salts (Cu^{2+}) are also relatively insoluble. Cu^{2+} forms coordination compounds or complexes with inorganic and organic ligands such as ammonia, chloride, and humic acids. These complexes tend to enhance both its solubility and its adsorption to clay and other surfaces. In soils, copper is strongly adsorbed and most of it remains within the upper few centimeters of soil.

Lead

Lead exists in the 2+ and 4+ valence states. Sorption to sediments is the dominant fate process of lead in natural waters. Precipitation with hydroxides, carbonate, sulfate, and sulfide results in decreased dissolved lead concentrations. Lead undergoes specific adsorption at mineral interfaces, precipitation of sparingly soluble solids, and formation of relatively stable organic-metal complexes/chelates with organic matter. Complexation of lead with organic matter increases its adsorptive affinity for clays and other mineral surfaces. Lead is strongly retained by most soils.

Manganese

Six oxidation states exist for manganese: 1+, 2+, 3+, 4+, 6+, and 7+ (with 2+, 3+, 4+, and 7+ being the most common). From pH 4 to pH 7, Mn^{2+} predominates; above pH 8, the higher oxidation states dominate. The principle anion associated with Mn is CO_3^{2-} ; $MnCO_3$ is relatively insoluble. Most of the manganese present in the soil will likely be present in the 2+ valence state. In oxidizing environments, manganese solubility is controlled by oxidation of Mn^{2+} to Mn^{3+} and Mn^{4+} . In reducing environments, manganese solubility is controlled by the poorly soluble manganese sulfide.

Silver

Silver exists in two oxidation states: 1+ and 2+. Silver occurs primarily as sulfides and in association with iron, lead, tellurides, and gold. Under oxidizing conditions in surface water and soils, the primary silver compounds are bromides, chlorides, and iodides, while under reducing conditions, the free metal and silver sulfide predominate. In surface water, silver exists as a monovalent ion, as part of more complex ions with chlorides and sulfates, and by adsorbing onto particulate matter. Both the silver halides and silver sulfide have very low aqueous solubilities. Soil mobility is affected by drainage, redox conditions, pH, and organic matter content. Silver is strongly adsorbed to manganese and iron oxides, organic matter, and clay minerals.

Thallium

Thallium typically exists in the environment combined with other elements such as oxygen, sulfur, and the halogens. Thallium valence states are 1+ and 3+. These compounds are generally quite soluble in water. Thallium is typically found as the monovalent ion (Tl^+), but may be trivalent (Tl^{3+}) in very oxidizing environments. In surface water, thallium often precipitates as a sulfide (Tl_2S). Thallium tends to adsorb to soils and sediments.

Zinc

Zinc occurs in the environment primarily in the 2+ oxidation state. Zinc is likely to be strongly sorbed in soil; however, soil conditions (i.e., sorption potential and pH) will affect the tendency of zinc to be sorbed. In waters, the metal often forms complexes with a variety of organic and inorganic compounds and partitions into sediments. Therefore, sorption of zinc is the dominant fate of this metal in the aquatic environment.

Volatile Organic Compounds

Three VOCs were identified as PCOCs: vinyl chloride (sediment); cis 1,2-dichloroethene (surface water); and trichloroethene (surface water).

In general, the partition of VOCs between different media reflects a dynamic equilibrium unless volatilization is hindered. Volatilization is expected to be a dominant transport mechanism leading to the escape of VOCs from surface waters. Additionally, these compounds may be quite mobile in soils and tend to leach to ground water. In the presence of elevated soil organic carbon content, the VOCs would be expected to sorb to the organic carbon. The routes of migration in the environment for these compounds are discussed below.

Where present in surface waters or on soil surfaces, the halogenated VOCs identified as PCOCs will predominantly volatilize into the atmosphere. These compound are moderately to highly mobile in soil and susceptible to significant leaching. In subsurface regions where volatilization cannot occur, these compounds are slowly to moderately degraded.

B. Site Conceptual Model

Based on an evaluation of pre-existing site data, affected environmental media, PCOCs, PAOCs, and potential exposure routes were identified as a preliminary Site Conceptual Model (SCM) in the PSE report. As discussed in the RI/FS Work Plan, the Site Conceptual Model was modified and supplemented as necessary during the course of the RI, as RI/FS data were collected and evaluated. The generalized SCM presented in tabular form below was prepared at the culmination of the Phase 2 investigation (November 2003) and was used as a preliminary gauge of the constituents, areas, media and pathways to be evaluated in the HHRA and ERSE. However, the generalized SCM was not used to limit or focus the body of site data used in the initial screening stages of the risk assessments. PCOCs listed in the SCM include constituents identified as PCOCs in the PSE Report using pre-RI site data, but which were not confirmed as PCOCs following completion of Phases 1 and 2 of the RI (i.e., chromium and lead in surface water).

Notwithstanding the preliminary information presented for the residue piles summarized in the following tables, the residue piles were not explicitly considered as potential exposure media to either human or ecological receptors in the risk assessments. The large size of the residue pieces that comprise the piles precludes exposure via ingestion, inhalation, or dermal contact, nor are the piles attractive to ecological receptors for purposes of habitation, nesting, or foraging. However, the residue piles were implicitly included in the risk assessments as potential primary sources of metals. That is, the degree of mobility of metals contained in the residues is represented in the existing on- and off-site soil, sediment, surface water, and ground water data that were used to estimate the potential risks to defined human and ecological receptor populations. However, as discussed in Section VIII.D of this report, potential human and ecological risks that may be associated with exposure to materials in the residue piles will be explicitly assessed as an addendum to the risk assessments.

POTENTIAL CONTAMINANTS OF CONCERN (PCOCs)					
On-Site Soil	Sediment – Western Drainageway	Sediment – Eastern Drainageway	Residues	Ground Water	Surface Water
Analytical Fractions					
TAL-Metals	TAL-Metals	TAL-Metals	TCLP Metals	TAL-Metals	TAL-Metals
Cadmium	Antimony	Antimony	TCLP-Lead	Cadmium	Cadmium
Lead	Arsenic	Arsenic		Lead	Chromium
Zinc	Beryllium	Beryllium		Manganese	Copper
	Cadmium	Cadmium		Thallium	Lead
	Lead	Lead		Zinc	Manganese
	Silver	Silver		Iron	Zinc
	Thallium	Thallium			Iron
	Zinc	Zinc			
	Organics	Organics		Other Inorganics	Other Inorganics
	Vinyl Chloride	Vinyl Chloride		Sulfate	Sulfate
					Organics
					Cis 1,2-Dichloroethene
					Trichloroethene

POTENTIAL AREAS OF CONCERN (PAOCs)				
On-site Soil	Sediment	Residues	Ground Water	Surface Water
Area 1; Area 2; Area 3; Area 4 Western Area	Western Drainageway; Eastern Drainageway	RR1 Stockpiles; RR2 Stockpiles; MP Stockpiles	SW Part of Site and Off-Site Area Immediately Adjacent	Western Drainageway; Eastern Drainageway

POTENTIAL EXPOSURE ROUTES							
	On-Site Soil	Residues	On-Site Sediments	Off-Site Sediments	On-Site Ground Water	Off-Site Ground Water	Surface Water
Potentially Affected Population	Construction Worker; Employee; Trespasser; Future Resident ²⁹ ; Ecological Receptors	Construction Worker; Employee; Trespasser; Ecological Receptors	Construction Worker; Employee; Trespasser; Future Resident ³⁰ ; Ecological Receptors	Resident; Ecological Receptors	Construction Worker; Employee; Future Resident ²⁹	Resident	Construction Worker; Employee; Trespasser; Future Resident; Ecological Receptors
Exposure Route(s)	Ingestion/ Inhalation; Soil Leaching to Ground Water; Potential Ecological Impacts	Ingestion/ Inhalation; Residue Leaching to Ground Water	Ingestion/ Inhalation; Soil Leaching to Ground Water	Ingestion/ Inhalation; Soil Leaching to Ground Water; Potential Ecological Impacts	Ingestion	Incidental Residential Exposure	Secondary Residential Exposure; Potential Ecological Impacts

³⁰ This scenario is hypothetical, as residential development of the Site is not permitted under current zoning ordinances and a deed restriction that limits future use of the site to commercial/industrial was filed with the Montgomery County Recorder of Deeds on November 4, 2004.

VI. HUMAN HEALTH RISK ASSESSMENT

A. Introduction

1. Purpose

This section presents the human health risk assessment (HHRA), which was performed to quantitatively evaluate potential current and future human health risks associated with the Site under continued commercial industrial land use conditions. Specifically, the objectives of the HHRA are to:

- Provide an analysis of potential receptor-specific risks, assuming no remedial action or institutional control;
- Provide a basis for estimating maximum acceptable concentrations of Constituents of Potential Concern (COPCs) in Site media based on risk levels that adequately protect human health; and
- Determine which media may require remediation, institutional controls, or further evaluation.

This HHRA was developed in accordance with applicable EPA guidance and multiple discussions with EPA Region V personnel.

2. Guidance Used

This HHRA was performed in accordance with applicable EPA guidance, including:

- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A* (EPA 1989) ("RAGS");
- *Risk Assessment Guidance for Superfund Volume I, Human Health Evaluation Manual, Part B* (EPA 1991a);
- *Soil Screening Guidance: Technical Background Document* (EPA 1996);
- *Supplemental Guidance to RAGS: Calculating the Concentration Term* (EPA 1992);
- *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (EPA 2002c);
- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part E* (EPA 2001a);
- *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (EPA 2002a);

- *Exposure Factors Handbook* Volumes I through III (EPA 1997a, 1997b, 1997c); and
- *Child-Specific Exposure Factors Handbook* (EPA 2002b).

3. Components of Human Health Risk Assessment

The human health risk assessment process typically involves five basic elements:

- **Data Review and Evaluation:** Review of available data to (1) characterize the Site, (2) define the nature and magnitude of releases to environmental media (soil, air and water), and (3) identify COPCs (i.e., chemicals that are associated with the Site and present in concentrations higher than background levels and conservative risk-based COPC screening levels), potentially complete exposure pathways, and human receptors (i.e., people that could come in contact with COPCs).
- **Exposure Assessment:** Estimation of the amount, frequency, duration, and routes of receptor exposure to COPCs. The exposure assessment considers both current and likely future site uses, and is based on receptor scenarios that define the conditions of exposure to COPCs. The potential magnitude of exposure to defined receptors is determined by estimating the representative concentrations of COPCs available in environmental media at various portals of entry to the body (i.e., the lungs, gastrointestinal tract, or skin). Exposure scenarios are summarized in the exposure pathway conceptual site model (CSM) for the Site (Figure VI-1).
- **Toxicity Assessment:** Review of available information to (1) identify the nature and degree of toxicity of each COPC, and (2) characterize the dose-response relationship (the relationship between magnitude of exposure and magnitude of adverse health effects) for each COPC. The EPA has developed chronic toxicity criteria for many chemicals for use in human health risk assessment. These values are not expected to result in adverse health effects even under lifelong exposure conditions. In addition, subchronic toxicity values are available for a smaller number of chemicals. These values are used to evaluate risk for scenarios with less-than-lifetime exposure (e.g., construction workers).
- **Risk Characterization:** Synthesis of exposure and toxicity information to (1) determine the nature and magnitude of potential cancer risks and non-cancer hazards at a site, and (2) estimate what residual levels of chemicals do not pose unacceptable risks to potential receptors.
- **Uncertainty Analysis:** Qualitative and/or quantitative assessment of the sources, magnitude, and effects of uncertainty and variability in the exposure and toxicity parameter values, assumptions, and models used. An uncertainty analysis accounts

for the variability in measured and estimated parameters, allowing decision-makers to better evaluate risk estimates in the context of the assumptions and data used in the assessment.

4. Tiered Approach to Human Health Risk Assessment at the Eagle Zinc Company Site

To ensure that protection of human health and the environment remains the focus of remedial activities at the Site, a two-tiered risk-based approach was used to (1) identify areas that may require further investigation, and (2) develop risk-based remedial target levels for affected media. This approach is depicted as a decision tree in Figure VI-2, and briefly described below.

a. Tier 1

In Tier 1, concentrations of COPCs at receptor exposure points are screened against chemical-, pathway-, and medium-specific criteria referred to as Tier 1 screening levels. Tier 1 screening levels are defined as concentrations of COPCs in relevant media that are not expected to produce any adverse health effects under chronic exposure conditions associated with all potentially complete exposure pathways identified in Table VI-1 and Figure VI-1. Tier 1 screening levels for carcinogenic and non-carcinogenic effects are based on a target cancer risk of 10^{-6} , and a target non-cancer hazard quotient of 1, respectively.

To ensure consistency, equations and parameter values from EPA guidance (EPA 1989, 1991a, 1992, 1996, 1997a-c, 2001, 2002a-c) are preferentially used to calculate Tier 1 screening levels for each potentially complete exposure pathway. For potentially complete exposure pathways not considered in EPA guidance, Tier 1 screening levels are based on conservative (upper-bound) exposure and modeling assumptions in order to ensure a similar degree of conservatism.

Because of the conservatism of Tier 1 screening levels, no further risk assessment will be performed for areas where cumulative Tier 1 hazards/risks are below acceptable target levels. For areas where target hazard risk levels are exceeded, interim or final remedial action may be considered, or a Tier 2 assessment may be performed.

b. Tier 2

The distinction between generic screening levels and appropriate target levels for remediation is explicit in EPA guidance (e.g., EPA, 1991a). Indeed, the guidance states that exceedance of generic screening levels does “not establish that cleanup to meet these goals is warranted.” If Tier 1 screening levels are exceeded for any potentially

complete exposure pathways, and interim or final remedial action is considered impracticable, then site-specific, health-protective Tier 2 remedial target levels may be calculated.

The equations used in Tier 2 follow the same general methodology used to generate

Tier 1 screening levels, but actual site conditions, more sophisticated fate and transport models, COPC-specific chemical properties, and more realistic exposure assumptions will be incorporated as necessary and appropriate to develop Tier 2 remedial target levels. As in Tier 1, Tier 2 criteria are based on a target cancer risk level of 10^{-6} and a target non-cancer hazard quotient of 1.

No further risk assessment will be performed for areas where cumulative Tier 2 hazards/risks are below acceptable target levels. Where these levels are exceeded, interim or final remedial strategies may be considered.

5. Document Organization

The Tier 1 HHRA for the Site is organized into the following additional sections:

- *Section B, Data Review and Evaluation* provides a summary of the data collected at the Site, the selection process for identifying COPCs, the methodology used in the development of representative concentrations for the COPCs, and related uncertainties.
- *Section C, Exposure Assessment* describes the exposure pathway CSM and potential receptor scenarios representing relatively highly exposed populations that form the framework of the HHRA, identifies conservative exposure parameter values selected to represent a reasonable maximum estimate (RME) magnitude and frequency of contact via potentially complete exposure pathways, and describes uncertainties related to these elements.
- *Section D, Toxicity Assessment* briefly describes the toxicity assessment process and lists toxicity and risk-based criteria for all COPCs in the HHRA and related uncertainties.
- *Section E, Development of Tier 1 Screening Levels* describes the methods and assumptions used in deriving Tier 1 screening levels for each of the receptor scenarios.
- *Section F, Tier 1 Risk Characterization* compares representative concentrations of COPCs in potential exposure media with relevant Tier 1 screening levels for each receptor scenario to calculate Tier 1 cancer risks and non-cancer hazard indices.

- *Section G. Summary and Conclusions* recapitulates the purpose, methods, results, and conclusions of the HHRA.

B. Data Review and Evaluation

1. Site Characterization

Site characterization information is summarized in previously submitted ENVIRON documents (ENVIRON 2002a&b, 2003a&b).

a. Site Location and Description

The location and characteristics of the Site are discussed in detail in Section I.B.1 above.

b. Land Use

Land use in the vicinity of the Site is discussed in Section I.B.1 above. The Site property is zoned for commercial industrial use, and local officials have indicated to ENVIRON that there are no plans to re-zone the property for other uses.

On November 4, 2004, T.L. Diamond recorded an EPA-approved enforceable deed restriction on the entire property that will run with the land and will limit future use of the property to industrial commercial purposes. Documentation from the City of Hillsboro that it intends that the property will be used for industrial purposes as part of its overall comprehensive plan is provided as Appendix VI-1. Therefore, this HHRA is based on the assumption that future land use at the Site will remain commercial/industrial, and does not include consideration of hypothetical future residential development.

2. Selection of Chemicals of Potential Concern for Risk Assessment

The first step of the risk assessment process is an evaluation of all available data to (1) characterize conditions at the Site, (2) develop a data set for use in the HHRA, and (3) identify COPCs. Previous documents have summarized site characterization information and described the data set (ENVIRON 2003a&b). COPCs are the focus of the risk assessment process. The following COPC selection criteria were applied to the risk assessment data set(s):

- Associated with former Site activities;
- Positively detected in more than 5% of samples;

- Positively detected in at least one sample at levels above Illinois background levels, if available; and
- Positively detected in at least one sample at levels above applicable COPC screening levels.
- A decision tree depicting the selection process is shown in Figure VI-3.

Screening levels for selection of COPCs in soil and sediment are defined as the higher of Illinois background levels (if available) and EPA Region 3's Risk-Based Concentrations (RBCs) for the default residential exposure scenario (EPA Region 3 2003a). These values are considered a conservative tool for COPC screening because they are calculated using EPA RAGS methodology (i.e., they are based on EPA-approved toxicity criteria and exposure rates that are not expected to cause cancer risk greater than 10^{-6} , or non-cancer hazard quotient greater than 1), are updated frequently (twice a year), and are consistently stringent. For example, RBCs are in most cases lower than corresponding Tier 1 remediation objectives developed under the IEPA's TACO.

Because the exposure rates expected for Site-specific non-residential exposure scenarios are substantially less than those assumed in the default residential scenario used in the calculation of the RBCs, chemicals at levels below the RBCs are not expected to contribute measurably to overall risk. In the case of potential carcinogens, use of a target risk level of 10^{-6} in the RBCs is expected to be protective of possible exposure to multiple carcinogenic COPCs based on EPA's acceptable cancer risk range of 10^{-6} to 10^{-4} (EPA 1991b). Because RBCs for non-carcinogenic chemicals were developed on the basis of childhood-only (i.e., more intensive) exposures, their use in COPC screening is expected to be protective of cumulative hazards from exposures to multiple non-carcinogens in non-residential receptors. Thus, as recommended by EPA Region 3, it is appropriate to use these conservative screening levels to distinguish those COPCs that are significant contributors to potential risks from those that have minimal impact (EPA Region 3 1993).

For evaluation of samples taken in soil and sediment, the residential soil RBC was used as the COPC screening level. Since EPA Region 3 did not specify RBCs for lead, concentrations in surface and subsurface soil were compared to the action level of 400 mg/kg (EPA 2002a). As ground water is not used for drinking, and such use is not anticipated in the future because there is a public water supply (see Section VI.C.4 below), no evaluation of the soil protective of ground water pathway was included in the HHRA. For screening of samples taken in surface water and ground water, tap water RBCs were used. In the absence of a Region 3 tap water RBC for lead, the MCL of 0.015 mg/L (EPA 2003c) was used for COPC screening. Because the majority of mercury in abiotic media is expected to be in the inorganic state, mercury was conservatively evaluated as mercuric chloride (corrosive sublimate).

Although the majority of chromium in the environment is in the reduced (trivalent) state, chromium was conservatively assumed to be in the more toxic hexavalent state for purposes of screening.

Some of the compounds included in the EPA analytical methods have no associated EPA-approved toxicity values and hence lack Region 3 RBC values to which a comparison could be made. In such cases, either (1) a surrogate compound with approved toxicity criteria was selected, or (2) an RBC was calculated based upon toxicity factors located in the Texas Commission on Environmental Quality's document, Texas Risk Reduction Program (TCEQ 2003):

- Acenaphthene was selected as a surrogate for acenaphthylene; pyrene, for benzo(g,h,i)perylene and phenanthrene; xylenes, for *o*-xylene and *m+p*-xylenes; and
- 1,3-dichloropropene, for *cis*-1,3-dichloropropene and *trans*-1,3-dichloropropene.
- RBCs were calculated for 2-hexanone, 2-nitrophenol, 4-bromophenyl phenyl ether,
- 4-chloro-3-methylphenol, 4-chlorophenyl phenyl ether, 4-methyl-2-pentanone,
- 4-nitrophenol, bis(2-chloroethoxy)methane, chloromethane, cyclohexane, and methylcyclohexane.

To ensure that analytes are not spuriously screened out due to elevated detection limits, detection limits for analytes with no or few positive detections were also compared with COPC screening levels. If the maximum detection limit exceeded the COPC screening level in more than 5% of analyses, then the analyte was retained for qualitative consideration in the uncertainty analysis.

The Region 3 RBCs and Illinois background values used for COPC screening are listed in Table VI-2. Summaries of the COPC screening level selection process are presented in Tables VI-3, VI-4, VI-5, and VI-6 for soil, sediment, ground water, and surface water, respectively. Analytes identified as COPCs based upon this screening process are summarized in Table VI-7.

3. Calculation of Representative Concentrations

A representative concentration is defined as the concentration of a COPC in a given medium to which human receptors may be exposed. The representative concentration is subsequently compared with Tier 1 screening levels (Section VI.E) to estimate Tier 1 cancer risk and non-cancer hazard (Section VI.F). Because of the uncertainties associated with any estimate of exposure concentrations, EPA has developed a conservative approach in which the lower of the 95% upper confidence limit (UCL) on the mean or the maximum compound concentration (detected concentration or reported detection limit) is used to determine the

representative concentration for the media of interest. The 95% UCL was calculated in accordance with the methodology presented in *Supplemental Guidance to RAGS: Calculating the Concentration Term* (EPA 1992) and *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (EPA 2002c).

In the calculation of the 95% UCL, all non-detected results were assigned a proxy value equal to one-half the reported detection limit as is consistent with EPA (1989). For duplicate samples, if the compound was detected in both samples, then the average of the analytical values was used to represent the compound concentration in the evaluation. If the compound was detected in neither sample then one-half of the smallest reported detection limit was used as the representative concentration. If the compound was detected in one sample, but not detected in the other, the detected concentration was used as the representative concentration. The methods used are detailed in Appendix VI-2.

The 95% UCLs were calculated as described above only for on-Site soil and ground water. As discussed in Section IV.B.6, available data and information concerning the residue piles do not suggest that air deposition has impacted off-Site areas. A detailed evaluation of all historical data for the Site, including the off-Site soil data collected by IEPA in 1993 as part of the CERCLA Expanded Site Inspection, indicated that no constituent concentrations detected in off-Site soils were determined to be significantly different from Site-specific background levels. While arsenic concentrations were determined to be different from the level detected in a local background sample, the highest detected concentration was only marginally above the average regional background level, as reflected by the non-MSA background value presented in the Illinois TACO. In addition, arsenic is not known to have been used or released at the Site. As the off-Site soil samples collected by IEPA in 1993 were well-distributed around the Site, the available data do not indicate any detectable impacts to off-Site soils from constituents associated with the Site. The original SOW for the RI/FS did not include off-Site soil sampling because the historical data did not suggest that this was a potential area of concern. Subsequent evaluation of possible migration pathways to off-Site soils documented in the technical memoranda (ENVIRON 2003a&b) also did not indicate a need for collection of off-Site soil data. Therefore, off-Site soil was not considered as a potential exposure medium in the HHRA.

To characterize constituent concentrations in on-Site soils, a specific number of borings (established in the SOW and RI/FS Work Plan) were completed at locations randomly selected from a 50 x 50-foot grid within each of seven areas of the Site (Areas 1-4, Manufacturing Area, Western Area, Northern Area). Because these areas do not represent actual or anticipated human activity patterns, receptor presence is considered equally likely in all areas, and sample locations were biased to locations exhibiting elevated XRF field screening levels, all available soil data were combined to calculate representative

concentrations of soil COPCs for use in the HHRA. None of the borings were conducted through residue piles; however, some of the borings randomly fell within areas containing accumulations of surficial residues. Soils from each boring were screened for metals using XRF and organic vapors using a PID. The EPA-approved sampling methodology (also established in the SOW and RI FS Work Plan) involved retaining samples for laboratory TAL metals analysis from a specific number of borings exhibiting the highest metals concentrations determined using XRF. The soil samples for laboratory analysis were collected immediately below any surface residues present at the randomly selected location. Based on a lack of PID screening results above background levels, a subset of the TAL metals samples was randomly selected for analysis of TCL organics and PCBs. The locations of the soil borings, borings for which soils were retained for laboratory analysis, and concentrations detected above conservative screening levels used to evaluate the data are shown on Figure III-6. Soil data and representative concentration calculations are presented in Appendix VI-2.

Constituents present in ground water were characterized from samples taken in March of 2003 in all newly installed permanent and temporary monitoring wells and all pre-existing wells, except for wells MW-A, MW-B, MW-D, MW-E, and G-108. All of the wells were sampled for TAL metals and sulfate. In addition, four of the ground water samples (MW1, MW4, MW8, and G107) were analyzed for TCL organic compounds and PCBs. The metals analyses were conducted using both field-filtered and unfiltered samples to determine dissolved and total metals concentrations, respectively. Ground water data and representative concentration calculations are presented in Appendix VI-2.

No determination of UCLs was performed for surface water and sediment locations since only data from the surface water and sediment sampling locations closest to Lake Hillsboro (SW-ED-16 and SD-ED-16, respectively) were used to characterize potential exposure of people using the Lake for drinking water, fishing, or recreational purposes. The maximum concentrations of COPCs in the surface water and sediment samples taken in the southwestern area of the Site (near the pond) were used as representative concentrations for Trespasser exposure. The values, UCLs or maximum detected concentrations, used as representative concentrations in potential exposure media are presented in Table VI-8.

4. Uncertainties Related to Data Review and Evaluation

a. Uncertainty Related to the Selection of Representative Concentrations

The representative concentrations presented in this section were conservatively estimated as the lower of the 95% UCL of the mean of the data set and the maximum detected value. The representative concentrations were also assumed to remain constant

over the chronic exposure duration of the HHRA. Despite the existence of other sources in the Hillsboro area, it is conservatively assumed that all COPCs are Site-related.

As discussed in Section VI.B.3, 95% UCLs could only be calculated for the compounds identified as COPCs in soil and ground water. Receptors using Lake Hillsboro for drinking water (Off-Site Adult and Child Residents), recreational purposes (Off-Site Recreational Bather), and fishing (Off-Site Recreational Fisher) were evaluated using data from the sample point closest to Lake Hillsboro. Although dilution of COPCs in the Lake would be very large, it was not quantified. Similarly, the maximum concentrations of COPCs in the surface water and sediment samples from the southwestern area of the Site (near the pond) were used as representative concentrations for the Trespasser scenario. Therefore, the representative concentrations selected to represent long-term sediment and surface water exposure concentrations for these receptors are extremely conservative.

b. Uncertainty Related to Exclusion of Non-Detected Compounds

As indicated in Tables VI-3 through VI-6, a limited number of analytes that were never positively detected in soil, sediment, ground water, and surface water data sets had detection limits that exceeded their respective RBCs. The majority of these analytes are volatile and semi-volatile organic compounds that are not expected to be associated with the Site based upon historical activities, and indeed were seldom detected in any media. As such, it is not expected that their exclusion from the HHRA will result in underestimation of potential risk/hazard associated with the Site.

C. Exposure Assessment

The objective of the exposure assessment is to estimate the type, magnitude, frequency, duration, and routes of the potential human exposures to the COPCs identified in Section VI.B.2. The exposure assessment is based upon scenarios that define the conditions of exposure to COPCs. These scenarios are summarized in the exposure pathway CSM presented in Figure VI-1, which represents our understanding of the sources of COPCs, the means by which they are released and transported within and among media, and the exposure pathways and routes by which they may contact human receptors. The CSM provides the framework for the development of the risk and hazard associated with each COPC, exposure pathway, and receptor. As shown in Figure VI-1, the CSM includes:

- Known or potential sources of COPCs;
- Environmental media that may be affected by COPCs, including surface water, ground water, soil, sediment, air, and biota;

- **Primary and secondary release mechanisms that may be associated with each affected medium;**
- **Potential exposure pathways for defined receptors, based on collected data or expected pathways; and**
- **Potential human receptor populations.**

A brief discussion of the components of the CSM is presented in the following sections.

1. Sources

Historical industrial activities at the Site are assumed to be the sources of COPCs present in residue piles, soil, sediment, ground water, and surface water.

2. Potential Migration Pathways

Potential migration pathways at the Site were evaluated in the Phase 2 Technical Memorandum (ENVIRON 2003b). With the exception of trichloroethylene in drainageway sediments and surface water, the COPCs in Site media are all metals. The concentration and distribution of COPCs in environmental media on and in the vicinity of the Site could be (and/or could historically have been) affected by one or more of the following general mechanisms, as illustrated in Figure VI-4 and Figure VI-5:

- **Airborne emissions during historical industrial operations;**
- **Suspension and transport of particle-associated COPCs in air;**
- **Suspension and transport of particle-associated COPCs in surface water runoff;**
- **Leaching of COPCs from residue piles to underlying soil;**
- **Desorption of COPCs from subsurface soil particles and leaching into underlying ground water;**
- **Migration of dissolved COPCs in ground water; and**
- **Ground water-to-surface water transport of COPCs.**
- **As discussed in Section IV.B. 6 above, available data and information concerning the residue piles indicate that there is no evidence that air deposition has impacted off-Site areas. The prevailing wind direction is from the south and south-southwest. Therefore, any impact would be the greatest in the area immediately north or north-northeast of the areas used for residue storage. A previous investigation conducted by IEPA addressed this issue through the collection of off-Site surficial soil samples (see Section I.B.3). None of these data suggest that off-Site migration of contaminants through wind deposition has occurred. Since no on-Site soil impacts in**

the Northern Area of investigation were identified in the Phase I investigation, and existing off-Site data show no impacts, off-Site air erosion of residue piles and subsequent deposition is not considered a viable contaminant transport pathway at the Site.

3. Potential Receptor Populations

Potential receptor populations to be considered include:

- On-Site Commercial/Industrial Workers (present and future);
- On-Site Construction Workers (future);
- Trespassers (present and future);
- Off-Site Residents (present and future);
- Off-Site Recreational Bathers in Lake Hillsboro (present and future); and
- Off-Site Recreational Fishers in Lake Hillsboro (present and future).

Because the Site's historical, current, and anticipated future use is commercial/industrial, the assumption that future residential development of the Site will not occur is considered valid. Accordingly, the most appropriate on-Site exposure scenario is the commercial/industrial worker. The construction worker exposure has also been evaluated to ensure that people engaged in intrusive activities at the Site are protected. Although the magnitude of exposure to any trespassers accessing the Site would be much less than that experienced by workers, this scenario was also considered in the risk assessment in light of evidence that trespassing has occurred at the Site.

The off-Site receptors with potential for exposure to COPCs are area residents and recreational users of water bodies receiving runoff and ground water-to-surface water flow from the Site. The off-Site portion of the Western Drainageway immediately downstream of the southwest pond is not known to be used, nor does it have a reasonable potential to be used, for recreational purposes. The stream is intermittent (has been observed to be nearly dry during summer months) and small (typically 5-6 feet wide and several inches deep when flowing). The portion of the drainageway immediately west of the site is relatively inaccessible, as it is located in an area that is: (1) heavily overgrown with brush; (2) extremely marshy; (3) in a basin that is surrounded to the north, south, and east by steep upward slopes; and (4) located on private property, most of which is owned by Fuller Brothers Concrete. No residential properties are intersected by, or back directly up to the drainageway. Therefore, regular recreational bathing by area residents is to occur only in Lake Hillsboro. Intake of COPCs potentially accumulated in fish tissue by recreational fishers in Lake Hillsboro is also evaluated.

The following exposure scenarios are intended to encompass the spectrum of potential exposures that could plausibly occur at a site intended for commercial/industrial use:

- **On-Site Commercial/Industrial Worker:** represents the long-term adult receptor who works as a full-time employee at the Site and whose typical responsibility is maintenance or other activities performed primarily outdoors. The activities for this receptor might include moderate digging or landscaping in surface to shallow subsurface soil. As the on-Site Commercial Industrial Worker receptor is expected to be the most highly exposed receptor in the outdoor environment, risk and hazards for this receptor would be expected to be higher than any other on-Site receptor. The point of exposure (POE) for this receptor is identified as any location on-Site.
- **On-Site Construction Worker:** represents adults who have short-term exposure to compounds in soil during a single construction project. If multiple non-concurrent projects are anticipated, it is assumed that different workers will be employed for each project. The activities for this receptor typically involve substantial exposure to both surface and subsurface soils. This receptor is expected to have a higher soil contact rate than the typical commercial industrial worker. The POE for this receptor is identified as any location on-Site.
- **Trespasser:** represents individuals (assumed to be adolescents aged 12 to 17 years) who make repeated unauthorized entries and wander freely over the Site during the summer. This receptor could be exposed to compounds in on-Site soil, sediment, and surface water. The POE for this receptor for on-Site soil exposure could be anywhere on the Site. The POE considered for exposure to sediment and surface water was considered to be the southwestern stormwater retention pond. As indicated in Section VI.B.3, the maximum concentrations of COPCs in surface water and sediment samples taken in the southwestern area of the Site (near the pond) were used as representative concentrations for this receptor scenario.
- **Off-Site Resident:** represents individuals (adult and child) living in the vicinity whose public water supply system occasionally draws upon Lake Hillsboro (the POE; used as a backup water source for only 1.5 weeks in 2003). These receptors could be exposed through potable use (ingestion and dermal contact), although the limited use of Lake Hillsboro water makes this potentially complete exposure pathway very unlikely to be significant. Furthermore, surface water samples collected from Lake Hillsboro by IEPA near the potable water intake in 2001 contained no constituent concentrations above federal MCLs. Off-Site residents are not expected to be present on the Site at any time. As data from the reservoir would be reflective of many inputs, data from the closest surface water sampling point to

the reservoir (SW-ED-16) were used to provide a conservative estimate of exposure to COPCs. That is, no dilution within Lake Hillsboro was assumed.

- **Off-Site Recreational Bather:** represents individuals (adult and child) living in the vicinity who regularly swim outdoors during the summer. Because off-Site areas receiving drainage from the southwest area of the Site do not appear to be large or accessible enough to support regular recreational activity, the POE for the Recreational Bather is identified as Lake Hillsboro. Like the Off-Site Resident, data from the surface water sampling point nearest Lake Hillsboro were used to provide a conservative estimate of exposure, without accounting for dilution in the Lake.
- **Off-Site Recreational Fisher:** represents individuals (adult and child) who frequently catch and consume fish from Lake Hillsboro (the POE). In the absence of fish tissue data, fish concentrations were estimated by multiplying the concentrations of COPCs in the surface water sampling point nearest Lake Hillsboro by COPC-specific bioconcentration factors (BCFs). Again, dilution of COPCs in the Lake was not accounted for.

4. Potentially Complete Exposure Pathways

Exposure pathways consist of four elements:

- A source and mechanism(s) of constituent release to the environment;
- An environmental transport medium for the released constituent;
- A point of potential human contact with the affected medium; and
- A route of entry into humans (inhalation, ingestion, or dermal contact with the affected medium).

If any of these components is missing, then the pathway is incomplete and does not contribute to receptor exposure. The rationale for selection of potentially complete exposure pathways to be evaluated in Tier 1 of the HHRA is presented in Table VI-1 and briefly discussed in the following sections.

a. Exposure to Soil

Direct exposure to on-Site COPCs in soil is possible for receptors located on-Site (commercial/industrial worker, construction worker, and trespasser) via:

- Incidental ingestion of surface and/or subsurface soil;
- Dermal contact with surface and/or subsurface soil; and

- **Inhalation of respirable dust particles that have become entrained in the air.**

As discussed in Sections VI.C.2 and VI.C.3, available data and information indicate that off-Site soils have not been impacted by the Site, and that residue piles are not sources of airborne dust either on- or off-Site.

b. Exposure to Ground Water

The City of Hillsboro has been served by a municipal potable water system since the existing water treatment plant was constructed in 1926. Recent searches of public and private water wells have been conducted by ENVIRON and Philip Environmental Services (summarized in ENVIRON 2002a). The well searches were requested from the Illinois State Water Survey (ISWS), the IEPA, and the Illinois State Geological Survey. Additional information provided by the Montgomery County Health Department and City of Hillsboro officials is also presented in the PSE Report. While there are records of some older domestic wells located within a one-mile radius of the Site, all residents of Hillsboro, as well as unincorporated areas located within one mile of the Site, are provided with public water.

The ISWS search showed a group of private wells located in an area immediately west of Lake Hillsboro. According to Hillsboro Mayor William Baran, this area, known as Lakewood Knolls, was connected to the public water supply during the 1980s and 1990s, either at the time the homes were built, or later, when the municipal water lines were installed in these areas. The small older residential area located in the same area, but south of Smith Road, is also supplied with public water. According to a local ordinance, "...any connection whereby a private, auxiliary or emergency water supply other than the regular public water supply enters the supply or distribution system of the City..." is prohibited. According to Mr. Scott Hunt of Hurste-Roche, Inc., the City's engineering firm, the prohibition of cross-connections would preclude the use of a separate domestic well water system within a household that is connected to the municipal water system. Although local officials have indicated that some older domestic wells may be used for non-potable outdoor purposes (e.g., watering lawns and gardens), it is unlikely that significant ingestion occurs, and there is no expectation that ground water resources will be developed for potable use in the foreseeable future.

Based on the available information, it is concluded that potable ground water is not a complete exposure pathway. Since no volatile organic compounds were detected above RBCs, the volatilization from the ground water exposure pathway was also considered to be incomplete.

Discharge of ground water into surface water bodies could be a source of COPCs to on- and off-Site surface water bodies. The bulk of the Site's ground water is believed to flow either southwestward (towards and parallel with the Western Drainageway) or eastward/southeastward (towards and parallel with the Eastern Drainageway) (ENVIRON 2003b) (Figures VI-4 and VI-5). On-Site areas within the Eastern Drainageway include large non-operational areas (e.g., Northern Area and areas east of the Manufacturing Area) and lack significant source areas, such as residue piles. The fact that no dissolved metals were detected above applicable ground water screening levels in these wells (ENVIRON 2003b) reflects the lack of source areas that could impact ground water in the areas east of the Site. Thus, available data indicate that ground water flow to the Eastern Drainageway and Lake Hillsboro is not a significant exposure pathway. Based on the limited off-Site extent of ground water impacted by dissolved metals concentrations to the southwest of the Site, it is similarly concluded that discharge of ground water is not a significant pathway for the off-Site transport of COPCs to the southwest.

Finally, construction workers engaged in intrusive activities on the Site could come into direct contact with ground water in excavations. This exposure pathway is expected to be trivial due to the low level of expected exposure and the relative lack of dermal permeation by metals, the only COPCs. Nonetheless, it was quantitatively considered in the HHRA as a potentially complete exposure pathway.

c. Exposure to Surface Water

Surface water impact could occur due to COPCs being carried off-Site in storm water runoff (Figures VI-4 and VI-5). In May 2003, the IEPA terminated the Site's National Pollutant Discharge Elimination System (NPDES) Permit, which regulated storm water discharges from the former plant to both the eastern and western storm water outfalls, because, according to the IEPA's May 23, 2003 *Public Notice/Fact Sheet of Intent to Terminate NPDES Permit No. IL0074519*, "...the facility has closed, all industrial activity has ceased, and the discharges have ceased."

Although significant off-Site transport may no longer be occurring, individuals could encounter COPCs in surface water impacted by historical releases during recreational activities (i.e., Trespassers in the area of the southwest pond and Off-Site Recreational Bathers in Lake Hillsboro) or through consumption of fish caught in Lake Hillsboro (Off-Site Fishers). As mentioned previously, in the absence of fish tissue data, concentrations were estimated by multiplying the representative concentrations of COPCs at the surface water sampling point nearest Lake Hillsboro by COPC-specific BCFs.

Nearby off-Site residents whose public water occasionally draws upon Lake Hillsboro could be exposed through domestic use (ingestion and dermal contact), although as noted previously, the limited use of Lake Hillsboro water (used as a backup water source for only 1.5 weeks in 2003) makes this potentially complete exposure pathway very unlikely to be significant. Furthermore, surface water samples collected from the reservoir by IEPA near the potable water intake in 2001 contained no constituent concentrations above federal MCLs.

d. Exposure to Sediment

Sediment in the nearby creeks and ponds, both on- and off-Site, may have been impacted by compounds contained in the runoff from storm water events. As discussed previously (Section VI.C.4.c), available data suggest that off-Site impacts are related to historical surface water runoff from the Site rather than ongoing discharges.

Nonetheless, both Trespassers who may swim in the southwest pond area and Off-Site Recreational Bathers of Lake Hillsboro could be exposed through incidental ingestion of sediment impacted by historical releases. Because dermal contact with sediment is expected to be of insufficient quantity and duration to result in significant exposure, it was not considered quantitatively in the HHRA.

5. Selection of Exposure Parameter Values for Calculation of Tier 1 Screening Levels

Exposure parameters are variables that describe the physical characteristics and medium contact rates of the populations selected for evaluation. A combination of high-end and central tendency values for exposure and physical parameters were selected so that in combination, they result in an estimate of the RME for each pathway. The RME is intended to be representative of high-end (but not worst-case) exposures. In most cases, published exposure parameter values were incorporated in this risk evaluation; where default values were lacking, professional judgment was relied upon to achieve a similar level of conservatism. The exposure parameter values used in this HHRA for each receptor, along with their technical basis, are presented in Tables VI-9 through VI-14. These exposure parameter values, along with other compound and site-specific information, were used to develop the Tier 1 screening levels described in Section VI.E.

6. Uncertainties Related to Exposure Assessment

Each of the assumptions made and parameter values used to estimate the magnitude of exposure for the human exposure scenarios considered has associated uncertainty and variability. To ensure that potential risks to human health are not underestimated, most of these assumptions and values were deliberately intended to overestimate potential exposure:

- The exposure pathways evaluated were those expected to have the largest impact on risk and hazard;
- Parameter values intended to result in RME exposure estimates were selected for all potentially complete pathways;
- As discussed in Section VI.B.3, the representative concentrations were conservatively estimated as the lower of the 95% UCL of the mean of the data set or the maximum detected value; and
- As noted above, (Section VI.C.3) COPC concentrations in fish tissue were estimated in the absence of monitoring data by applying published BCFs. In the case of zinc, an essential metal, the BCF is not useful for relating uptake to adverse effects because zinc is (and must be) naturally concentrated by living organisms. Further, the fact that many organisms are capable of regulating internal zinc concentrations means that they are physiologically equipped to compensate for perturbations or high concentrations in the external environment. Thus, zinc tissue concentrations do not necessarily reflect ambient concentrations and, in contrast to those for lipophilic organic compounds, zinc BCFs cannot be considered to be constant ratios between tissue concentrations and external water concentrations. Accumulation of zinc to meet physiological requirements should not be mistaken for trophic transfer; it is not biomagnified (Beyer 1986; Suedel et al. 1994; WHO 2001).

Taken together, these conservative assumptions are highly likely to result in overestimation of exposure to the receptor populations considered in this HHRA, to an unknown but probably significant degree.

D. Toxicity Assessment

The toxicity assessment characterizes the relationship between the magnitude of exposure to a COPC and the nature and magnitude of adverse health effects that may result from such exposure. Toxicity criteria for use in risk assessment may be based on epidemiological studies, short-term human studies, or subchronic or chronic animal data. Toxicity criteria for COPCs at the Site were selected (in order of preference in accordance with EPA 2003b) from the following sources: (1) EPA's Integrated Risk Information System (IRIS) (EPA 2004b); (2) EPA's provisional peer-reviewed toxicity values developed by the Office of Research and Development/National Center for Environmental Assessment/Superfund Health Risk Technical Support Center; and (3) EPA's *Health Effects Assessment Summary Tables* (HEAST) (EPA 1997d) and other tertiary sources. The systemic and carcinogenic effects of TCE have been under EPA review for a number of years, and recently proposed values (EPA 2001b) are being reevaluated. In the absence of approved toxicity criteria for this compound, both withdrawn and proposed values will be used in the HHRS.

Chemical toxicity is divided into two categories, carcinogenic and non-carcinogenic, based on the type of adverse health effect exerted. Health risks are calculated differently for these two types of effects because their toxicity criteria are based on different mechanistic assumptions and expressed in different units. The two approaches are discussed below.

1. Toxicity Indicators for Non-Carcinogenic Effects

A non-carcinogenic effect is defined as any adverse response to a chemical that is not cancer. Any chemical can cause adverse health effects if given at a high enough doses. When the dose is sufficiently low, no adverse effect is observed. Thus, in characterizing the non-cancer effects of a chemical, the key parameter is the threshold dose at which an adverse effect first becomes evident. Doses below the threshold are considered to be "safe" (i.e., not associated with adverse effects), while doses above the threshold may cause an adverse effect.

The threshold dose is typically estimated from toxicological data (derived from studies of humans and/or animals) by finding the highest dose that does not produce an observable adverse effect (the "No-Observed-Adverse-Effect-Level (NOAEL)) and the lowest dose at which an adverse effect is observed (the "Lowest-Observed-Adverse-Effect-Level (LOAEL)). The threshold dose is presumed to lie in the interval between the NOAEL and the LOAEL. In order to be conservative or protective of particularly sensitive potential receptors, non-cancer risk evaluations are not based directly on the threshold exposure level, but on a value referred to as the Reference Dose (RfD).

An RfD is an estimate of the daily lifetime exposure level to humans (expressed in units of mg of chemical/kg of body weight/day), including sensitive subgroups, that is likely to be without appreciable risk of deleterious effects (EPA 1989). Reference concentrations (RfCs) are concentrations in air (in units of mg per cubic meter – mg/m^3) that an individual may be exposed to every day for a lifetime without harm. RfDs and RfCs are usually derived from NOAELs (or LOAELs, if reliable NOAELs are not available) from studies in the most sensitive species, strain, and sex of experimental animal known, the assumption being that humans are no more sensitive than the most sensitive animal species tested. These criteria incorporate a series of uncertainty factors representing inter- and intraspecies variability and the quality and completeness of the toxicological database. These uncertainty factors (with one exception) are assigned a value of at least 10. If human studies are available and the observations considered reliable, the uncertainty factor may be as small as 1. The effect of dividing the NOAEL or the LOAEL by the product of all the uncertainty factors is to ensure that the RfD or RfC is not higher than the threshold level for adverse effects in the most sensitive potential receptor. Thus, there is a "margin of safety" built into an RfD or RfC, and doses equal to or less than the RfD or RfC are nearly certain to be without any adverse effect. The likelihood of an adverse effect at doses higher than the RfD or RfC increases, but because

of the margin of safety, a dose above the criterion does not mean that such an effect will necessarily occur.

Under the guidelines established by the Superfund program, exposures to construction workers of one year or less are classified as subchronic (defined as less than seven years [EPA 1989]). Because this is short relative to the working lifetime (25 years) generally assumed for workers, it is appropriate to evaluate potential non-cancer hazard by comparison of estimated exposure with toxicity values for subchronic, not chronic, effects (EPA 2002a). Accordingly, subchronic values have been used as available in this risk assessment. In the absence of subchronic values for COPCs, chronic values were used.

Current non-carcinogenic toxicity information for the identified COPCs (up-to-date as of March 2004) is presented in Table VI-15, and physicochemical properties are listed in Table VI-16. In the case of exposure by dermal contact with soil, if the compound-specific gastrointestinal absorption factor (ABS_{GI}) value (Table VI-16) is less than 50%, the RfD will be multiplied by the ABS_{GI} . If the ABS_{GI} is greater than or equal to 50%, then the reported oral RfD, will be used. The RfDs for cadmium, manganese, vanadium, and zinc were adjusted to account for gastrointestinal absorption. Available subchronic non-cancer toxicity values, indicated in Table VI-15, were used for the construction worker scenario.

2. Toxicity Indicators for Carcinogenic Effects

Cancers are generally defined as diseases of mutation affecting cell growth and differentiation. In contrast to non-carcinogenic effects, EPA traditionally assumes that there is no threshold for carcinogenic responses; that is, any dose of a carcinogen is considered to pose some finite risk of cancer. The evidence for human carcinogenicity of a chemical is derived from two sources: chronic studies with laboratory animals and human epidemiology studies where an increased incidence of cancer is associated with exposure to the chemical. The EPA typically assumes that negative epidemiological data are not evidence that a chemical is not carcinogenic in humans.

Since risks at the low levels of exposure usually encountered by humans are difficult to quantify directly by either animal or epidemiological studies, mathematical models are used to extrapolate from high experimental to low environmental doses. The slope of the extrapolated dose-response curve is used to calculate the cancer slope factor (CSF), which defines the incremental lifetime cancer risk per unit of carcinogen (in units of risk per mg/kg/day). The linearized multi-stage model for low-dose extrapolation most often used by EPA (EPA 1986, 2003a) is one of the most conservative available, and leads to an upper-bound estimate of risk (the 95% UCL of the modeled animal dose-response slope). Under the assumption of dose-response linearity at low doses, the probability that the true potency is higher than that estimated is thus only 5 percent. Actual potency (and resultant risk) is likely to be lower, and

could even be zero (EPA 1986). Recent guidance provides for derivation of dose-response relationship using alternative low-dose-response extrapolation procedures as indicated by the nature and quality of the database (EPA 2003a).

Current carcinogenic toxicity information for the identified COPCs (up-to-date as of March 2004) is presented in Table VI-15. In the case of exposure by dermal contact with soil, if the compound-specific ABS_{GI} value (Table VI-16) is less than 50%, the CSF will be divided by the ABS_{GI} . If the ABS_{GI} is greater than or equal to 50%, then the reported oral CSF will be used. None of the CSFs presented in Table VI-15 were adjusted to account for gastrointestinal absorption.

3. Lead

The EPA has deemed it inappropriate to develop either an RfD or a CSF for inorganic lead. A great deal of information on the health effects of lead has been obtained over the past 60 years of medical observation and scientific research. Inorganic lead may be absorbed by inhalation or by ingestion. Absorption by either route contributes in an additive fashion to the total body burden. Infants are born with a lead burden (lead present in their body) that primarily reflects the mothers' past exposure. Infants and children are exposed to lead mainly from ingestion of food and beverages and the ingestion of non-food materials by normal early mouthing behavior. The impact that the mouthing behavior has on the blood lead level depends on the levels of lead in house dust, soil, and paint. Most adults are exposed to lead primarily from dietary sources (food and water), but occupational exposure to lead may be significant in some circumstances.

Instead of dose-based toxicity criteria, potential risk associated with lead exposure is assessed by means of blood lead levels. The EPA has established a target blood lead level for children less than eight years of age, who are particularly susceptible to lead toxicity, of no more than 10 $\mu\text{g}/\text{dL}$ for both short- and long-term exposures. This level is based on the occurrence of enzymatic alterations in erythrocytes at blood lead levels below 25 $\mu\text{g}/\text{dL}$ and by reports of neurologic and cognitive dysfunction in children at blood lead levels between 10 and 15 $\mu\text{g}/\text{dL}$ (ATSDR 1997). Using an integrated exposure uptake-biokinetic (IEUBK) model that is specifically designed to predict blood lead levels, a lead concentration in soil at which there is no more than a 5 percent chance that exposure would result in exceedance of the target blood lead level for children (10 $\mu\text{g}/\text{dL}$) is 400 mg/kg (EPA 1994a).

4. Uncertainties Related to Toxicity Assessment

The uncertainties associated with dose-response relationships and weight-of-evidence carcinogenicity classification is generally much greater than those associated with other elements of risk assessment. The extrapolation of high-dose animal bioassay or occupational

exposure study results to estimate human risk at much lower levels of exposure involves a number of conservative assumptions regarding effects thresholds, interspecific responses, high- to low-dose extrapolation, and route-to-route extrapolation. The scientific validity of these assumptions is uncertain; because each of the individual extrapolations are designed to prevent underestimation of risk, in concert they result in unquantifiable but potentially very large overestimation of risk/hazard. Other sources of uncertainty in the toxicity assessment that could result in over- or underestimation of risks include:

- Extrapolation of oral RfDs and CSFs to other exposure routes;
- Use of toxicity criteria that have been withdrawn or do not represent EPA consensus values (e.g., trichloroethylene); and
- Extrapolation among exposure media, which introduces uncertainty due to lack of knowledge of matrix effects on chemical bioavailability.

E. Development of Tier 1 Screening Levels

Equations used for calculating Tier 1 screening levels for the potentially complete exposure pathways at the Site are discussed in the following sections. RME exposure parameter values for each receptor scenario are presented along with sources in Tables VI-9 through VI-14, toxicity criteria are listed in Table VI-15, and other required chemical/physical properties for COPCs are displayed in Table VI-16. The target hazard quotient (THQ) is 1, and the target cancer risk level (TR) is 10^{-6} , the lower bound of EPA's acceptable risk range of 10^{-6} to 10^{-4} (EPA 1991b).

Receptor scenario-specific Tier 1 screening levels for the On-Site Commercial/Industrial Worker, On-Site Construction Worker, Trespasser, Off-Site Recreational Bather, Off-Site Resident, and Off-Site Fisher are presented in Tables VI-17, VI-18, VI-19, VI-20, VI-21, and VI-22, respectively.

1. Soil and Sediment

Tier 1 screening levels for direct contact with surface and subsurface soil and sediment via individual exposure routes (soil ingestion, dermal contact, and inhalation of particles) were calculated for all on-Site receptor scenarios and the Off-Site Recreational Bather. Because the duration of exposure for the On-Site Construction Worker scenario is subchronic (defined as less than seven years [EPA, 1989]), subchronic toxicity criteria (EPA 1997d), as available, were used instead of chronic RfDs in calculating Tier 1 screening levels.

a. Incidental Ingestion of Soil and Sediment

Tier 1 screening levels for incidental ingestion of soil by On-Site Commercial/Industrial Workers and Construction Workers and incidental ingestion of

soil and sediment by Trespassers were calculated in accordance with Equation {1}:

$$Ingestion SL_{Soil/Sed} = \frac{THQ \text{ or } TR \cdot BW \cdot AT \cdot 365 \text{ days/yr} \cdot [RfD \text{ or } 1/CSF]}{ED \cdot EF \cdot 10^{-6} \text{ kg/mg} \cdot SIR \text{ or } SedIR} \quad \{1\}$$

The equation used to calculate Tier 1 screening levels for incidental sediment ingestion by the combined child and adult Recreational Bather is:

$$Ingestion SL_{Sed} = \frac{THQ \text{ or } TR \cdot AT \cdot 365 \text{ days/yr} \cdot [RfD \text{ or } 1/CSF]}{EF \cdot 10^{-6} \text{ kg/mg} \cdot SedIR_{adj}} \quad \{2\}$$

The age-adjusted sediment intake rate ($SedIR_{adj}$) was calculated by analogy to the equation used by EPA to estimate age-adjusted soil intake rates (EPA 1991a):

$$SedIR_{adj} = \frac{SedIR_a \cdot ED_a}{BW_a} + \frac{SedIR_c \cdot ED_c}{BW_c} \quad \{3\}$$

where:

Parameter	Units	Description
$Ingestion SL_{Soil/Sed}^a$	mg/kg	Tier 1 Screening Level for incidental ingestion of soil or sediment
BW	kg	Body weight [population-specific]
BW_c	kg	Child body weight [population-specific]
BW_a	kg	Adult body weight [population-specific]
AT	yr	Averaging time [population-specific]
CSF	(mg/kg-day) ⁻¹	Oral carcinogenic slope factor [chemical-specific]
RfD	mg/kg-day	Chronic or subchronic oral reference dose [chemical-specific]
ED	yr	Exposure duration [population-specific]
ED_c	yr	Child exposure duration [population-specific]
ED_a	yr	Adult exposure duration [population-specific]
EF	days/yr	Exposure frequency [population-specific]
SIR/SedIR	mg/day	Incidental ingestion rate of soil or sediment [population-specific]
$SedIR_c$	liter/day	Child ingestion rate of sediment while swimming
$SedIR_a$	liter/day	Adult ingestion rate of sediment while swimming
$SedIR_{adj}$	mg-yr/kg-day	Age-adjusted sediment intake rate [population-specific]
THQ	unitless	Target hazard quotient
TR	unitless	Target cancer risk level
^a Equation {1} as presented in EPA (2002a) rearranged to solve for incidental ingestion only		

b. Dermal Contact with Soil

Tier 1 screening levels for dermal contact with soil by On-Site Commercial/Industrial Workers, Construction Workers, and Trespassers were calculated in accordance with Equation{4}:

$${}^{\text{DermalContact}}SL_{\text{Soil}} = \frac{\text{THQ or TR} \cdot \text{BW} \cdot \text{AT} \cdot 365 \text{ days/yr} \cdot [\text{RfD or } 1/\text{CSF}]}{\text{ED} \cdot \text{EF} \cdot 10^{-6} \text{ kg/mg} \cdot \text{AF} \cdot \text{SA} \cdot \text{EV} \cdot \text{ABS}_d} \quad \{4\}$$

where:

Parameter	Units	Description
${}^{\text{DermalContact}}SL_{\text{Soil}}^a$	mg/kg	Tier 1 Screening Level for dermal contact with soil
BW	kg	Body weight [population-specific]
AT	yrs	Averaging time [population-specific]
CSF	(mg/kg-day) ⁻¹	Dermal carcinogenic slope factor [chemical-specific]
RfD	mg/kg-day	Dermal reference dose [chemical-specific]
ED	yrs	Exposure duration [population-specific]
EF	days/yr	Exposure frequency [population-specific]
AF	mg/cm ²	Skin-soil adherence factor [population-specific]
SA	cm ² /event	Skin surface area exposure [population-specific]
EV	event/day	Event frequency [population-specific]
ABS _d	unitless	Dermal absorption factor [chemical-specific]
THQ	unitless	Target hazard quotient
TR	unitless	Target cancer risk level
^a Equation {4} as presented in EPA (2002a) rearranged to solve for dermal contact only		

c. Inhalation of Airborne Soil Particles

Tier 1 screening levels for inhalation of airborne soil particles soil by On-Site Commercial/Industrial Workers, Construction Workers, and Trespassers were calculated in accordance with Equation{5}:

$${}^{\text{Inhalation}}SL_{\text{Soil}} = \frac{\text{THQ or TR} \cdot \text{AT} \cdot 365 \text{ days/yr} \cdot [\text{RfC or } ((1/\text{URF}) \cdot 10^{-3} \text{ mg}/\mu\text{g})]}{\text{EF} \cdot \text{ED} \cdot (1/\text{PEF})} \quad \{5\}$$

where:

Parameter	Units	Description
Inhalation SL_a	mg/kg	Tier 1 Screening Level for inhalation of volatile compounds in soil or airborne particulates originating from soil
AT	yrs	Averaging time (equal to AT_{nc} for non-carcinogenic evaluation and AT_c for carcinogenic evaluation) [population-specific]
URF	$(\mu\text{g}/\text{m}^3)^{-1}$	Inhalation unit risk factor [chemical-specific]
RfC	mg/m^3	Inhalation reference concentration [chemical-specific]
EF	days/yr	Exposure frequency outdoor [population-specific]
ED	yrs	Exposure duration [population-specific]
PEF	m^3/kg	Particulate emission factor [calculated]
THQ	unitless	Target hazard quotient
TR	unitless	Target cancer risk level

^a Equation as presented in EPA (2002a)

The particulate emission factor (PEF), which is used to estimate the inhalation of wind blown particulates, was determined using the equation:

$$PEF = \frac{Q/C_{wind} \cdot 3600 \text{ sec/hr}}{0.036 \cdot (1 - V) \cdot \left(\frac{U_m}{U_t} \right)^3 \cdot F(x)} \quad \{6\}$$

where:

Parameter	Units	Description
PEF ^a	m^3/kg	Particulate emission factor
Q/C_{wind}	$(\text{g}/\text{m}^2 \cdot \text{sec}) / (\text{kg}/\text{m}^3)$	Inverse of mean concentration at center of a 132-acre square source [=41] ^b
V	unitless	fraction of vegetative cover [=0.5 default]
U_m	m/sec	Mean annual wind speed [=4.69 default]
U_t	m/sec	Equivalent threshold value of wind speed at 7 m [=11.32 default]
F(x)	unitless	Function dependent on U_m/U_t derived using Cowherd <i>et al.</i> (1985) [=0.194 default]

^a As specified in Equation B-8 of EPA (2002a)
^b Based upon the equation presented in Exhibit D-2 of EPA (2002a) using constants for Chicago, Illinois and a source area size of 132 acres.

d. Lead in Sediment

Lead is a COPC in sediment (Table VI-7). As noted in Section VI.D.3, the EPA has established a target blood lead level for children less than eight years of age, who are particularly susceptible to lead toxicity, of no more than 10 $\mu\text{g}/\text{dL}$ for both short- and long-term exposures. Using an IEUBK model that is specifically designed to evaluate blood lead levels in children, EPA has determined that 400 mg/kg represents the residential soil concentration at which there is no more than a 5% chance that the target blood lead level for children will be exceeded (EPA 1994b). As noted in Section

VI.D.3, this value was also selected for COPC screening. No comparable screening level is available for evaluation of a receptor exposed to lead contained in sediment. Due to the significant behavioral and physiological differences between young children and older people, the IEUBK model does not allow estimation of blood lead levels for persons older than eight years of age or for less than 350 days/year exposure frequency (EPA 1994a). Thus, modification of this value to match recreational and trespasser exposure scenarios is not appropriate. Therefore, 400 mg/kg was also used as a highly conservative screening level for sediment.

2. Surface Water and Ground Water

The equations in the following sections were used to calculate Tier 1 screening levels for:

- Direct contact with surface water via various individual exposure routes (incidental ingestion while swimming, ingestion as a potable source, and dermal contact) for Trespassers, Off-Site Recreational Bathers, and Off-Site Residents;
- Ingestion of fish in Lake Hillsboro by Off-Site Fishers; and
- Dermal contact with ground water in excavations for the On-Site Construction Worker scenario.

a. Incidental Ingestion of Surface Water While Swimming

Tier 1 screening levels for incidental ingestion of surface water while swimming by Trespassers were calculated in accordance with Equation {7}:

$$Ingestion\ SL_{SW} = \frac{THQ\ or\ TR \cdot BW \cdot AT \cdot 365\ days/yr \cdot [RfD\ or\ 1/CSF]}{ED \cdot EF \cdot {}^{swim}WIR} \quad \{7\}$$

The equation used to calculate Tier 1 screening levels for incidental surface water ingestion while swimming by the combined child and adult Recreational Bather is:

$$Ingestion\ SL_{SW} = \frac{THQ\ or\ TR \cdot AT \cdot 365\ days/yr \cdot [RfD\ or\ 1/CSF]}{EF \cdot {}^{swim}WIR_{adj}} \quad \{8\}$$

The age-adjusted incidental surface water intake rate while swimming (${}^{swim}WIR_{adj}$) was calculated in accordance with EPA Region 3 guidance (EPA Region 3 2003b):

$${}^{swim}WIR_{adj} = \frac{{}^{swim}WIR_a \cdot ED_a}{BW_a} + \frac{{}^{swim}WIR_c \cdot ED_c}{BW_c} \quad \{9\}$$

where:

Parameter	Units	Description
$^{Ingestion}SL_{SW}^a$	mg/liter	Tier 1 Screening Level for incidental ingestion of surface water while swimming
BW	kg	Body weight [population-specific]
BW_c	kg	Child body weight [population-specific]
BW_a	kg	Adult body weight [population-specific]
AT	hrs	Averaging time [population-specific]
CSF	$(mg/kg\text{-}day)^{-1}$	Oral carcinogenic slope factor [chemical-specific]
RfD	mg/kg-day	Oral reference dose [chemical-specific]
ED	hrs	Exposure duration [population-specific]
ED_c	hrs	Child exposure duration [population-specific]
ED_a	hrs	Adult exposure duration [population-specific]
EF	days/yr	Exposure frequency [population-specific]
^{swim}WIR	liter/day	Incidental surface water intake rate while swimming [population-specific]
$^{swim}WIR_a$	liter/day	Adult ingestion rate of surface water while swimming
$^{swim}WIR_c$	liter/day	Child ingestion rate of surface water while swimming
$^{swim}WIR_{adj}^b$	L-yr/kg-day	Age-adjusted surface water intake rate while swimming
THQ	unitless	Target hazard quotient
TR	unitless	Target cancer risk level

^a Equation {7} from EPA (1989), Exhibit 6-12, rearranged to calculate risk-based screening level
^b Calculated per Equation (2), EPA Region 3 (2003b)

b. Ingestion of Potable Surface Water by Off-Site Residents

Tier 1 screening levels for ingestion of potable surface water by the combined child and adult Off-Site Resident were calculated in accordance with Equation {10}:

$$^{Ingestion}SL_{SW} = \frac{THQ \text{ or } TR \cdot AT \cdot 365 \text{ days/yr} \cdot [RfD \text{ or } 1/CSF]}{EF \cdot WIR_{adj}} \quad \{10\}$$

The age-adjusted water intake rate (WIR_{adj}) was calculated in accordance with EPA Region 3 guidance (EPA Region 3 2003b):

$$WIR_{adj} = \frac{WIR_a \cdot ED_a}{BW_a} + \frac{WIR_c \cdot ED_c}{BW_c} \quad \{11\}$$

where:

Parameter	Units	Description
$^{Ingestion}SL_{SW}^a$	mg/liter	Tier 1 Screening Level for ingestion of surface water as a potable drinking source
AT	yrs	Averaging time [population-specific]
CSF	(mg/kg-day) ⁻¹	Oral carcinogenic slope factor [chemical-specific]
RfD	mg/kg-day	Oral reference dose [chemical-specific]
EF	days/yr	Exposure frequency [population-specific]
BW _c	kg	Child body weight [population-specific]
BW _a	kg	Adult body weight [population-specific]
ED _c	yrs	Child exposure duration [population-specific]
ED _a	yrs	Adult exposure duration [population-specific]
WIR _a	liter/day	Adult ingestion rate of potable surface water [population-specific]
WIR _c	liter/day	Child ingestion rate of potable surface water [population-specific]
WIR _{adj} ^b	liter-yr/ day-kg	Age-adjusted water ingestion rate
THQ	unitless	Target hazard quotient
TR	unitless	Target cancer risk level

^a Equation as presented in USEPA (1989), Exhibit 6-11
^b Calculated per Equation (2), EPA Region 3 (2003b)

c. Dermal Contact with Surface Water or Ground Water

Tier 1 screening levels for dermal contact with surface water (Trespasser) and ground water (On-Site Construction Worker) were calculated in accordance with Equation{12}:

$$^{DermalContact}SL_{SW/GW} = \frac{THQ \text{ or } TR \cdot BW \cdot AT \cdot 365 \text{ days/yr} \cdot [RfD_d \text{ or } 1/CSF_d]}{DA_{event} \cdot ED \cdot EF \cdot EV \cdot SA \cdot FSA \cdot 0.001 \cdot \text{liter/cm}^3} \quad \{12\}$$

where:

Parameter	Units	Description
$^{DermalContact}SL_{SW/GW}^a$	mg/kg/day	Tier 1 Screening Level for dermal contact with surface water
BW	kg	Body weight [population-specific]
AT	yrs	Averaging time [population-specific]
CSF _d	(mg/kg-day) ⁻¹	Dermal carcinogenic slope factor [chemical-specific]
RfD _d	mg/kg-day	Dermal reference dose [chemical-specific]
DA _{event}	cm/event	Absorbed dose per event [calculated see Exhibit 4-6a and 4-6b]
ED	yrs	Exposure duration [population-specific]
EF	days/yr	Exposure frequency [population-specific]
EV	events/day	Event frequency [population-specific]
SA	cm ²	Total skin surface area [population-specific]
FSA	unitless	Fraction of skin surface area available for exposure [population-specific]
THQ	unitless	Target hazard quotient
TR	unitless	Target cancer risk level

^a Equation{12} as presented in EPA (2001a), Equation 3.1.

The approach used to estimate the absorbed dose per event varies depending on whether the compound of interest is inorganic or organic. For inorganic COPCs, dermal absorbed dose per event is calculated as:

$$^{inorg}DA_{event} = K_p \cdot t_{event} \quad \{13\}$$

For organic COPCs, the method used to calculate dermal absorbed dose per event depends on the chemical-specific lag time per event (t_{event}). At the Site, the only organic COPC in surface water is trichloroethylene. Because this compound under assumed scenario conditions satisfies the condition that event duration (t_{event}) be less than or equal to the time required to reach steady-state (that is, the conservatively assumed event duration, 1 hour (Table VI-11), is less than the estimated time to reach steady state (t^* ; calculated as 2.4 x the lag time per event (0.58 hr/event) (EPA 2001a; Table VI-17)), or 1.4), the following equation was used to calculate dermal absorbed dose per event:

$$^{org}DA_{event} = 2 \cdot FA \cdot K_p \cdot \sqrt{\frac{6 \cdot \tau_{event} \cdot t_{event}}{\pi}} \quad \{14\}$$

where:

Parameter	Units	Description
$^{inorg}DA_{event}^a$	cm/event	Dermal absorbed dose per event for inorganic compounds
$^{org}DA_{event}^b$	cm/event	Dermal absorbed dose per event for organic compounds
FA	unitless	Fraction absorbed water [chemical-specific]
K_p	cm/hr	Dermal permeability coefficient of compound in water [chemical-specific]
t_{event}	hr/event	Event duration [population-specific]
t^*	hr	Time to reach steady-state [calculated as $2.4 \cdot \tau_{event}$]
τ_{event}	hr/event	Lag time per event [chemical-specific]
^a Equation { 13 } as presented in EPA (2001a), Equation 3.4, with compound concentration in water (C_w) removed.		
^b Equation { 14 } as presented in EPA (2001a), Equation 3.2, with compound concentration in water (C_w) removed.		

For the combined adult and child exposure scenarios (Off-Site Residents and Recreational Bathers), Tier 1 screening levels for dermal contact with surface water were calculated as:

$$^{DermalContact}SL_{SW} = \frac{THQ \text{ or } TR \cdot AT \cdot 365 \text{ days/yr} \cdot [RfD_d \text{ or } 1/CSF_d]}{DA_{event} \cdot EF \cdot EV \cdot SAF_{adj} \cdot FSA \cdot 0.001 \cdot \text{liter/cm}^3} \quad \{15\}$$

The age-adjusted dermal surface area factor (SAF_{adj}) was calculated in accordance with EPA guidance (EPA 2001a):

$$SAF_{adj} = \frac{SA_a \cdot ED_a}{BW_a} + \frac{SA_c \cdot ED_c}{BW_c} \quad \{16\}$$

where:

Parameter	Units	Description
DermalContact ^a SL _{SW}	mg/kg/day	Tier 1 Screening Level for Dermal Contact with Surface Water
AT	yrs	Averaging time [population-specific]
BW _c	kg	Child body weight [population-specific]
BW _a	kg	Adult body weight [population-specific]
CSF _d	(mg/kg-day) ⁻¹	Dermal carcinogenic slope factor [chemical-specific]
RfD _d	mg/kg-day	Dermal reference dose [chemical-specific]
DA _{event}	cm/event	Absorbed dose per event [calculated see Exhibit 4-6a and 4-6b]
ED _c	yrs	Child exposure duration [population-specific]
ED _a	yrs	Adult exposure duration [population-specific]
EF	days/yr	Exposure frequency [population-specific]
EV	events/day	Event frequency [population-specific]
FSA	unitless	Fraction of skin surface area available for exposure [population-specific]
SA _a	cm ²	Adult surface area exposed to water [population-specific]
SA _c	cm ²	Child surface area exposed to water [population-specific]
SAF _{adj}	cm ² -yr/kg	Age-adjusted dermal surface area factor for swimming or bathing
THQ	unitless	Target hazard quotient
TR	unitless	Target cancer risk level
^a Equation {15} modified from Equation 3.1 in EPA (2001a) to account for exposure as child and adult		

DA_{event} in Equation {15} is as defined in Equations {13} and {14}.

d. Ingestion of Recreationally Caught Fish

Tier 1 screening levels for ingestion of fish by combined child and adult Off-Site Recreational Fishers were calculated in accordance with Equation {17}:

$$^{Fish}SL_{SW} = \frac{THQ \text{ or } TR \cdot AT \cdot 365 \text{ days/yr} \cdot [RfD \text{ or } 1/CSF]}{EF \cdot BCF \cdot FIR_{adj}} \quad \{17\}$$

The age-adjusted fish intake rate (FIR_{adj}) was calculated by analogy to the equations used by EPA to estimate other age-adjusted intake rates:

$$FIR_{adj} = \frac{FIR_a \cdot ED_a}{BW_a} + \frac{FIR_c \cdot ED_c}{BW_c} \quad \{18\}$$

where:

Parameter	Units	Description
$^{Fish}SL_{SW}^a$	mg/L	Tier 1 Screening Level for ingestion of fish
AT	yrs	Averaging time [population-specific]
BW	kg	Body weight [population-specific]
BW _c	kg	Child body weight [population-specific]
BW _a	kg	Adult body weight [population-specific]
BCF	L/kg	Bioconcentration factor [chemical-specific]
CSF	(mg/kg-day) ⁻¹	Oral carcinogenic slope factor [chemical-specific]
RfD	mg/kg-day	Oral reference dose [chemical-specific]
ED _c	yrs	Child exposure duration [population-specific]
ED _a	yrs	Adult exposure duration [population-specific]
EF	days/yr	Exposure frequency [population-specific]
FIR _c	gm/day	Child recreational fish ingestion rate
FIR _a	gm/day	Adult recreational fish ingestion rate
FIR _{adj}	gm/day	Age-adjusted recreational fish ingestion rate
THQ	unitless	Target hazard quotient
TR	unitless	Target cancer risk level

^a Equation {17} as presented in EPA (1989), rearranged and modified to solve for intake due to ingestion as child and adult.

F. Tier 1 Risk Characterization

Risk characterization involves estimating the magnitude of the potential adverse health effects of the hazardous constituents under study and making summary judgments about the nature of the health threat to the defined receptor populations. It combines the results of the dose-response (toxicity) and exposure assessments to provide numerical estimates of health risk. Risk characterization also considers the nature and weight of evidence supporting these risk estimates as well as the magnitude of uncertainty surrounding such estimates.

In the Tier 1 risk characterization, Tier 1 screening levels for each COPC and medium were compared with representative concentrations in corresponding media to calculate Tier 1 hazard quotients (THQs) for non-carcinogenic effects and Tier 1 cancer risks (TICRs) for carcinogenic effects. EPA (2002a) has indicated that exposure via inhalation should be evaluated separately from direct contact exposure because of the potential for qualitative and quantitative differences in effects via the different routes. However, in keeping with the conservatism of this screening assessment, risks/hazards associated with all exposure routes were summed.

1. Calculation of Tier 1 Cancer Risks

TICRs for each receptor/route/pathway were calculated as the ratio of the representative concentration of a COPC in a given medium to the corresponding cancer Tier 1 screening level, multiplied by the target cancer risk level (10^{-6}):

$$\text{T1CR} = \frac{\text{Rep. Conc'n}}{\text{Tier 1 Screening Level}_{\text{cancer}}} \times \text{Target Risk Level} \quad \{19\}$$

To account for simultaneous exposure to multiple carcinogens through a given exposure route (e.g., ingestion of surface water), the risks calculated for each individual COPC encountered in a potential exposure medium via a given exposure route were summed to obtain a total risk for that medium/route.

For some potential exposure media, receptors could contact COPCs via more than one route (e.g., incidental ingestion and dermal contact with surface water). To account for simultaneous exposure to multiple routes associated with the same exposure medium, individual route risks were summed to obtain a total exposure medium risk. Finally, to account for simultaneous exposure to multiple exposure media, total risks for each medium were summed to estimate a cumulative incremental cancer risk.

2. Calculation of Tier 1 Hazard Quotients and Indices

The degree of exceedance of the non-cancer target level of 1 was estimated by calculating the ratio of COPC representative concentration in an exposure medium to the corresponding non-cancer Tier 1 screening level. This ratio is termed a T1HQ:

$$\text{T1HQ} = \frac{\text{Rep. Conc'n}}{\text{Tier 1 Screening Level}_{\text{non-cancer}}} \quad \{20\}$$

As with the carcinogenic evaluation, to account for simultaneous exposures, the T1HQs were summed as appropriate to produce a cumulative Tier 1 hazard index (T1HI) representing all potential exposures. The target level for the T1HI is also 1.

3. Risk Characterization Results

The risk characterization results for each receptor scenario are presented in Tables VI-23 through VI-28, discussed in the following sections.

a. On-Site Commercial/Industrial Worker

Estimated incremental lifetime cancer risks and non-cancer hazards to the On-Site Commercial/Industrial Worker scenario are summarized in Table VI-23. The cumulative T1CR was 5×10^{-6} , which is slightly above the EPA acceptable target risk value of 10^{-6} but well below the upper bound of EPA's target cancer risk range (10^{-4}). 99.5% of the estimated risk was due to arsenic. The representative concentration for

arsenic of 7.93 mg/kg is less than the Illinois background concentration of 11.3 mg/kg, but results in apparent exceedance of the 10^{-6} risk level because of the high degree of conservatism inherent in the arsenic toxicity criteria and the lack of consideration of the reduced bioavailability resulting from soil association. Indeed, the Illinois background concentration would result in an apparent risk of 6×10^{-6} . The fact that the representative concentration for arsenic of 8.09 mg/kg is less than the Illinois background concentration of 11.3 mg/kg indicates that this slight exceedance of the target risk level is insignificant.

The cumulative T1HI value was 0.2, one-fifth of the target level for non-cancer effects of 1. Iron, whose RfD is based upon the recommended daily allowance, contributed more than 40% of the T1HI.

These results indicate no unacceptable cancer risk or non-cancer hazard for this receptor population.

b. On-Site Construction Worker

Estimated incremental lifetime cancer risks and non-cancer hazards to the On-Site Construction Worker scenario are summarized in Table VI-24. The cumulative T1CR (8×10^{-8}) and T1HI (0.6) were both less than respective target levels. As with the Commercial/Industrial receptor, iron was the primary contributor to the T1HI, contributing more than 53%.

These results indicate no unacceptable cancer risk or non-cancer hazard for this receptor population.

c. Trespasser

Estimated incremental lifetime cancer risks and non-cancer hazards to the Trespasser scenario are summarized in Table VI-25. The cumulative T1CRs (1×10^{-7} and 1×10^{-7} to 2×10^{-7}) and T1HIs (both 0.05) calculated using withdrawn and proposed draft trichloroethylene toxicity criteria, respectively, were both well below respective target levels. Arsenic accounted for 100% of the cancer risk (via the incidental ingestion of sediment pathway), while iron was the major contributor to the T1HI.

Only two of the sediment samples collected at the Site, SD-WD-8 (450 mg/kg) and SD-WD-7 (2,700 mg/kg), had reported concentrations which exceeded the 400 mg/kg screening level for lead. These sampling locations are immediately off-Site to the south and southwest, respectively. As the 400 mg/kg screening value for residential exposure is based upon daily contact with soil, the fact that sediment levels exceed it in a few locations cannot be readily interpreted. It is highly improbable that occasional contact with sediment-associated lead could result in adverse human health effects. However, a

change to the physical condition of this off-site drainage area may result in increased human exposure, that, in turn, may result in unacceptable risks that require further evaluation.

These results indicate no unacceptable cancer risk or non-cancer hazard for this receptor population.

d. Off-Site Recreational Bather

Estimated incremental lifetime cancer risks and non-cancer hazards to the Off-Site Recreational Bather scenario are summarized in Table VI-26. The cumulative T1CRs (5×10^{-8} and 5×10^{-8} to 8×10^{-8}) and T1HIs (0.002 and 0.003) calculated using withdrawn and proposed draft trichloroethylene toxicity criteria, respectively, were both well below respective target levels. Arsenic accounted for 100% of the cancer risk (via the incidental ingestion of sediment pathway), while iron was the major contributor to the T1HI.

These results indicate no unacceptable cancer risk or non-cancer hazard for this receptor population.

e. Off-Site Resident

Estimated incremental lifetime cancer risks and non-cancer hazards to the Off-Site Resident are summarized in Table VI-27. The cumulative T1CR calculated using the withdrawn oral cancer slope factor for trichloroethylene was 7×10^{-8} , well below the target level of 10^{-6} . T1CRs calculated using the range of proposed draft slope factors for this compound were 1×10^{-7} and 3×10^{-6} , only slightly exceeding the target level of 10^{-6} when the upper bound slope factor is used. As none of the other relevant COPCs were carcinogenic, all potential cancer risk was contributed by trichloroethylene.

The cumulative T1HI of 0.1 was also less than the target level of 1. The major contributors to the T1HI were zinc (69%) and iron (19%). Use of the proposed draft reference dose for this compound resulted in a cumulative T1HI of 0.2.

These results indicate no unacceptable cancer risk or non-cancer hazard for this receptor population.

f. Off-Site Recreational Fisher

Estimated incremental lifetime cancer risks and non-cancer hazards to the Off-Site Recreational Fisher scenario are summarized in Table VI-28. The cumulative T1CRs (1×10^{-8} and 2×10^{-8} to 4×10^{-7}) and T1HI (both 0.9) calculated using withdrawn and proposed draft trichloroethylene toxicity criteria, respectively, were both below

respective target levels. All potential cancer risk was contributed by trichloroethylene, and nearly all of the non-carcinogenic T1HI was due to zinc.

These results indicate no unacceptable cancer risk or non-cancer hazard for this receptor population.

4. Uncertainties Related to Tier 1 Risk Characterization

The Tier 1 risk characterization process combines exposure and toxicity information to develop an estimate of the Tier 1 cancer risks and non-cancer hazards that may be posed by COPCs to defined receptor populations. As discussed in previous sections, each of the assumptions and parameters involved in these operations has finite associated uncertainty, or variability, or both. Major sources of uncertainty in risk assessment parameters include (1) natural variability; (2) lack of knowledge about basic physical, chemical, and biological properties and processes; and (3) assumptions in the models used to approximate key inputs. Perhaps the greatest degree of uncertainty is associated with the toxicity criteria.

Although toxicity criteria are intentionally highly conservative and therefore likely to overestimate potential risks and hazards, the lack of criteria for several COPCs prevents their quantitative consideration and therefore may tend to underestimate potential risks associated with these compounds. However, as analytes lacking EPA-approved toxicity criteria were generally not known to be related to former Site operations, their omission is not considered to underestimate risk.

For screening purposes, underestimation of potential exposure and risk is avoided through use of upper-bound values for most parameters, including representative concentrations of COPCs, neglect of all conditions that mitigate exposure, such as soil/sediment sorption (i.e., reduced bioavailability), and crude summing of all risks/hazards across all media. Thus, while this approach satisfies the requirement for protectiveness and affords a high degree of confidence that COPC concentrations lower than Tier 1 screening levels represent insignificant risk, it provides (1) no insight into the sources and magnitude of underlying uncertainties, (2) no indication of where calculated risks may fall in the distribution of actual risks, and (3) no context for interpretation of results that exceed the conservative Tier 1 criteria. As a result, the results of the Tier 1 risk characterization can be effectively used to eliminate source areas/pathways from further consideration where total T1CRs and T1HI are below target risk and hazard levels, but they cannot be used to draw conclusions about the existence of unacceptable risk where these targets are exceeded.

As indicated in Section VI.D, the risk and hazards calculated for trichloroethylene were based on both the withdrawn and proposed draft toxicity values presented in Table VI-15. Use of the proposed draft oral cancer slope factor range resulted in a 2- to 36-fold increase in estimated carcinogenic risk. Use of the proposed draft oral reference dose resulted in a 20-

fold increase in non-carcinogenic hazard. As discussed in Section VI.F.3.e, the only receptor whose potential Tier 1 cancer risk level slightly exceeds the target level of 10^{-6} on account of using the proposed draft slope factor range is the off-Site Resident, and only when the upper bound of the range is used (0.4 per mg/kg-day). Since the surface water concentration, 0.00039 mg/L, used in the estimation of this risk is the detection limit of trichloroethylene and the sampling point used is from the stream as it moves off the east side of the property rather than the actual exposure point (Lake Hillsboro), which is seldom drawn upon for potable use, this slight exceedance is not considered indicative of unacceptable risk.

G. Summary and Conclusions

The purpose of this Tier 1 HHRA was to quantitatively evaluate potential current and future human health risks associated with the Site under continued commercial/ industrial land use conditions. COPC-, pathway-, and medium-specific Tier 1 screening levels for carcinogenic and non-carcinogenic effects were calculated for each of six receptor populations using algorithms from EPA guidance parameterized with conservative default exposure parameter values and EPA-approved toxicity criteria. As a result, the cumulative T1CRs/T1HIs for the defined receptor populations are likely to significantly exaggerate potential risks/hazards.

Despite the uniformly conservative assumptions made in this HHRA, the results indicated that with one exception, all cumulative T1HIs are below the target level of 1, indicating little, if any, potential for adverse non-cancer health effects associated with the Site. Two sediment samples collected immediately south and southwest of the Site boundary contained levels of lead in excess of the highly conservative screening level (400 mg/kg), which is based on daily exposure of a young child to soil rather than occasional contact with aquatic sediment. Because the area of affected sediment is very limited and the screening level is based on a much more intensive exposure regime than could occur by occasional contact with sediment, the fact that the representative sediment concentration is exceeded cannot be interpreted as indicating risk. However, the fact that lead levels are elevated in this area may warrant further evaluation.

The only T1CRs greater than the target level of 10^{-6} were (1) 4×10^{-6} computed for the On-Site Commercial/Industrial Worker, due entirely to potential exposure to arsenic in surface soil, and (2) 3×10^{-6} computed for the off-Site Resident due to potential exposure to trichloroethylene in potable water from Lake Hillsboro when the upper bound of the proposed draft slope factor range is used. The representative concentration of arsenic (7.9 mg/kg) is below the Illinois background level (11.3 mg/kg), and arsenic was not used as a raw material and was not a product of Site operations. The detection-level value used as the representative concentration of trichloroethylene in Lake Hillsboro was obtained from a sampling location close to the Site, and as such does not represent conditions in Lake Hillsboro. Further, as discussed in Section VI.C, this water is seldom used for potable purposes, and surface water samples collected from the reservoir by IEPA near the potable

water intake in 2001 contained no constituent concentrations above federal MCLs. Thus, these slight exceedances of the lower bound of EPA's target cancer risk range are not interpreted as suggestive of an unacceptable risk to human health.

Because none of the cumulative TICRs THH exceeded target levels for either carcinogenic or non-carcinogenic effects, the results of this HHRA support the conclusion that under current and reasonably anticipated future conditions, COPCs at the Site pose no significant cancer risk or non-carcinogenic hazard to the six receptor populations considered in the HHRA. This conclusion comports with that reached by the Illinois Department of Public Health (IDPH) in its recent health consultation for this Site (IDPH 2002; included herein as Appendix VI-3). The IDPH health consultation was prepared before initiation of data collection activities for the RI/FS and the RI/FS risk assessments.

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VII. ECOLOGICAL RISK SCREENING EVALUATION

A. Introduction

This section presents the ecological risk screening evaluation for the Site. The Introduction provides an overview of the ecological risk screening approach presented below and the organization of the remainder of this section of the RI Report.

1. Ecological Risk Screening Approach

The ecological risk screening presented herein was conducted in a manner consistent with the Eagle Zinc Remedial Investigation Feasibility Study (RI/FS) Work Plan (ENVIRON 2002a; Appendix D: Baseline Risk Assessment Plan) as well as with appropriate United States Environmental Protection Agency (USEPA) ecological risk assessment (ERA) guidance (e.g., USEPA 1997; 1998; 2000a; 2001a). The ecological risk screening evaluation conducted for the Eagle Zinc Site is considered representative of current site conditions, and includes the following steps, as described in the Eagle Zinc Baseline Risk Assessment Plan (ENVIRON, 2002a):

- Step 1: Screening-level Problem Formulation and Ecological Effects Evaluation
- Step 2: Screening-level Preliminary Exposure Estimate and Risk Calculation
- Step 3: Problem Formulation

These three steps are components of the USEPA 8-Step ERA process, as illustrated on Figures VII-1 and VII-2. Steps 1 and 2 comprise the screening-level ecological risk assessment (SLERA), while Step 3 is the initial step of the baseline ecological risk assessment (BERA) (USEPA 1997; 2000a). A SLERA evaluates the potential risk to wildlife exposed to chemical constituents by providing a conservative estimate of the risks that may exist for wildlife, and incorporating uncertainty in a precautionary (i.e., conservative) manner. The purpose of a SLERA is to either indicate that there is a high probability that there are no ecologically significant risks for wildlife, or to indicate the need for additional consideration (USEPA, 1997; 2000a). Additional consideration may include additional chemical investigation, reevaluation of the SLERA, remedial action for reasons other than ecological risks, or a BERA (in which case the information developed in the SLERA is used to help focus the BERA). A BERA is more complex than a SLERA and typically incorporates more realistic wildlife exposure information. Only those wildlife receptors (and particular constituents) identified with potential risks in the SLERA are carried forward in a BERA.

Step 3 of the ERA process (i.e., Problem Formulation) is an opportunity for iterative refinement of potential risks using methods similar to those used in Steps 1 and 2 (USEPA

2000a; 2001b), as illustrated on Figure VII-2. Specifically, constituents of potential concern (COPCs) identified in the SLERA may be eliminated from further consideration based on the refinement of certain assumptions, such as reasonable chemical exposure estimates, background/reference location comparisons, and consideration of more realistic bioaccumulation potential. According to the USEPA (2000a):

“The Problem Formulation [i.e., Step 3] is commonly thought of in two parts: Step 3a and Step 3b. Step 3a serves to introduce information to refine the risk estimates from steps one and two. For the majority of Sites, ecological risk assessment activities will cease after completion of step 3a. At many Sites, a single deliverable document consisting of the reporting of results from steps 1, 2 and 3a may be submitted. At those Sites with greater ecological concerns, the additional problem formulation is called Step 3b. It is very important at this stage to perform a ‘reality check.’ Sites that do not warrant further study should not be carried forward.”

The use of Steps 1, 2, and, as necessary, 3a/3b for the evaluation of ecological risks at the Eagle Zinc Site was agreed upon in the RI/FS Work Plan (ENVIRON, 2002a), and reconfirmed during the stakeholder meeting of June 2, 2004. This meeting was attended by representatives of the responsible parties and their contractors, and the USEPA and its contractors. Technical issues discussed during the June 2nd meeting were summarized in a Technical Memorandum, dated June 7, 2004 (CH2MHill, 2004), and subsequent correspondence in response to USEPA’s comments on the Draft Ecological Risk Screening Report (ENVIRON 2004).

The ERA process produces a series of clearly defined scientific management decision points (SMDPs), as illustrated on Figures VII-1 and VII-2 (USEPA 1997; 2000a). The SMDPs represent critical steps in the process where ecological risk management decision-making occurs. Stakeholder meetings and project-specific communication about ecological risk assessment approaches (such as the meetings and correspondence described above) are beneficial in the identification and acceptance of the ERA methodologies used and, ultimately, the SMDPs. Generally, the following types of decisions are considered at the SMDPs:

- Whether the available information is adequate to conclude that ecological risks are negligible and, therefore, there is no need for any further action on the basis of ecological risk.
- Whether the available information is not adequate to make a decision at this point, and the ecological risk assessment process will continue.

- Whether the available information indicates a potential for adverse ecological effects, and a more thorough assessment or remediation is warranted.

2. Report Organization

The remainder of this report is organized as follows:

- Section VII.B – Step 1: Screening-Level Problem Formulation and Ecological Effects Evaluation
- Section VII.C – Step 2: Screening-Level Exposure Estimate and Risk Calculation
- Section VII.D – Step 3a: Refinement of Step 2 Screening-Level ERA Exposure Estimates and Risk Calculations (Baseline ERA Problem Formulation)

B. Step 1: Screening-Level Problem Formulation and Ecological Effects Evaluation

Step 1 of the SLERA involves the screening-level problem formulation and ecological effects evaluation. Step 1 is presented in Section VII.B.1 (screening-level problem formulation) and Section VII.B.2 (screening-level ecological effects evaluation).

1. Screening-Level Problem Formulation

The overall purpose of the screening-level problem formulation is to describe the environmental setting on the Site (hereafter referred to as “on Site”) and adjacent to the Site (hereafter described as “off Site”), and to provide a preliminary evaluation of ecological exposure pathways and assessment endpoints. The screening-level problem formulation serves to define the reasons for the SLERA and the methods for analyzing/characterizing risks (USEPA 1998). Information pertaining to Site characterization, potential receptors, and ecosystem characteristics is vital to the problem formulation, as is information on the sources and effects of the stressors (USEPA 1998). The screening-level problem formulation provides information used to establish the overall goals, breadth, and focus of an ERA (USEPA 1997; 1998). Once these are established, the problem formulation is used to develop a conceptual model for the ERA.

The screening-level problem formulation produces two outputs: (1) assessment endpoints that reflect the management and ecosystem attributes the endpoints are meant to protect; and (2) a conceptual Site model that describes the relationships between stressors and the assessment endpoints.

The remainder of this section presents the following components of the screening-level problem formulation for the Site:

- Environmental Setting
- Identification of Constituents Detected and Classification of Sediments
- Description of Constituent Fate and Transport Pathways
- Description of Constituent Mechanisms of Ecotoxicity
- Description of Potentially Exposed Receptors
- Identification of Potentially Complete Exposure Pathways
- Identification of Generic Assessment and Measurement Endpoints

a. Environmental Setting

The Eagle Zinc Site is located in the Township of Hillsboro, central Montgomery County, Illinois. The Site is approximately 132 acres in area in a mixed commercial/industrial and residential area east of Hillsboro. The Site was in continuous industrial use for 90 years (from 1912 until 2002). Operations at the Site included zinc smelting, and manufacture of sulfuric acid, metallic zinc, zinc oxide, and leaded zinc oxide. Activities on the Site had been declining over the past several years as industrial operations slowed down, and finally ceased in 2002. This decreasing human activity level allowed slow reclamation of physically disturbed areas by common opportunistic species. However, there are still large areas with sufficient physical alteration to provide little wildlife habitat, such as manufacturing and other process-related areas that offer little or no vegetative cover. This section describes:

- On Site industrial areas
- On Site and off Site non-industrial areas
- Off Site adjacent land use

The characterization of the environmental setting is based on field surveys by qualified environmental biologists and a Certified Ecologist. Field surveys were conducted on July 15, 2002, March 3, 2004, June 22, 2004, and October 20, 2004. The information used to develop this environmental setting is provided in Appendix A, as follows, with a narrative discussion provided in the remainder of this section:

- *Appendix A-1: USEPA Ecological Characterization Worksheet (1997)* – This worksheet documents the habitat on Site and in the vicinity of the Site.
- *Appendix A-2: A summary of species or sign observed during field surveys* – The summary of species or sign documents that wildlife is present on Site (and the observations described in Section VII.B.1.a provide insight into the wildlife

use of the Site, as well as allows for generalizations about the types of wildlife receptors that are likely to be exposed at the Site).

- **Appendix A-3: List of sensitive species habitats in USEPA's Hazard Ranking System** – Based on observations from several field surveys, it was determined that sensitive habitats, as defined in USEPA guidance (1997), are not present at the Site (except for limited examples of man-made wetlands).
- **Appendix A-4: Correspondence with Illinois Department of Natural Resources (ILDNR) personnel regarding threatened and endangered (T&E) species** – The presence/absence of T&E species was explicitly evaluated in consultation with ILDNR. This appendix documents correspondence on this matter. Specifically, the representative of the ILDNR concluded that, “according to the Illinois Natural Heritage Database, there are no endangered or threatened species within the Site area indicated, specifically Township 8 North, Range 4 West, Sections 1 & 12, Third Principal Meridian. Nor are there any listed species within 1 mile of the project Site boundaries.”
- **Appendix A-5: Photographs documenting Site conditions** – A broad range of photographs are provided as part of the characterization of the Site (Photographs 1 through 28). These photographs illustrate specific features relevant to this ecological risk screening.
- **Appendix A-6: The qualitative aquatic habitat assessment conducted in October 2004** – The information developed from this assessment, including maps, photographs, and field data sheets provide conclusive evidence that aquatic habitat associated with the Eastern and Western Drainages is severely limited in quality due to physical parameters (including low flow, lack of appropriate substrate and cover, lack of pools, lack of vegetative margins, sedimentation, and channelization).

i. On Site Industrial Areas

During nearly a century of Site operations, approximately 25 percent to 30 percent of the Site (or approximately 30 to 40 acres) was developed into and/or used for manufacturing areas, residue storage areas, raw material storage areas, railroad sidings, and paved/unpaved roadways. As is typical with the development of industrial properties, the use of the property involved the physical elimination of potential ecological habitat (e.g., clearing of land, construction of buildings, paving of roads, installation of railways). Currently, operations have ceased at the Site, but the physical structures remain (e.g., Photographs 1, 2, and 3). There are no plans for the restoration of functional habitat within the industrialized areas of the

Site because redevelopment of the Site with continued industrial land use is planned.

ii. On Site and Off Site Non-Industrial Areas

Current wildlife habitat and biological resources are present on Site in areas that are outside the former manufacturing area and residue storage areas. It is estimated that approximately 70 to 75 percent of the Site has some form of wildlife habitat; however, much of the on Site habitat is limited due to physical alteration from human land use (e.g., old fields previously landscaped, old fields previously used for agricultural purposes, and man-made aquatic structures). The following subsections describe the habitat that is present on and off Site.

Terrestrial Habitat

As indicated on Figure VII-3, the terrestrial habitat on Site and in proximity to the Site includes woods, old fields, mixed woods, and grasses. The terrestrial habitats on Site are not considered sensitive habitats under the USEPA Hazard Ranking System (1997; Appendix A-3). Terrestrial habitats on Site are similar to those available in the surrounding area (the surrounding area will be described in greater detail in Section VII.B.1.c). Terrestrial habitats are shown in Appendix A-5 (Photographs 4 through 12; note that terrestrial habitat can also be seen along drainages in other photographs as well). Habitats such as these can support terrestrial wildlife, such as birds, mammals, and herpetofauna (i.e., reptiles and amphibians).

Open Field Habitat

Terrestrial areas, such as the open field present in the northern area (Figure VII-3 and Photographs 11 and 12), provide cover and wildlife habitat, yet there are indications of physical impacts due to previous land use. The old field habitat in the northern section of the Site was previously used for agricultural purposes. This type of habitat will progress through natural successional changes if not maintained. Young successional woody species (and in some areas, wetland grass species) were observed in June 2004, suggesting a relatively recent change in management strategy allowing the woody species to colonize. The old field habitat to the west of the manufacturing area was also maintained in some manner during Site operations, as evidenced by the fact that significant successional changes to the woodlands were not obvious as recently as June 2003.

Mixed Woods and Woodland Habitats

Mixed woods and woodland habitat also provide habitat and cover away from the manufacturing and open residue areas. For example, trees adjacent to drainages provide diverse habitat (Figure VII-3 and Photographs 13 through 25). Specifically, trees in the mixed woods are generally about 10 to 15 years old (Photographs 17 through 20), while in the woodlands some trees are apparently much older. Songbirds, including northern cardinal, were heard and observed in the mixed woods and woodlands.

Physical Alteration to Habitat: Catalpa Trees

Although terrestrial wildlife habitat is present on Site, it is limited in areas due to the physical alteration of habitat. For example, it has been previously noted that stands with dead catalpa (*Catalpa speciosa*) trees are in close proximity to the manufacturing area (north/northwest). Dead trees were reportedly observed in the late 1980s, and at other occasions since that time, including 2004. A Certified Ecologist conducted a field survey in June 2004, with particular attention given to the dead catalpas. Based on the field survey and a review of relevant literature, there is sufficient evidence to suggest that the mortality of the catalpa is not directly related to elevated chemical residues because:

- Dead trees were observed at the northern extreme of the Site, away from areas impacted by the Site.
- Apparently robust saplings were observed growing in residue material.
- Dead trees were collocated with hydric soils atypical of the species preferred habitats.
- Recent succession to *Salix* species (i.e., willows, which are a hydrophilic species) was noted in areas with inundation.
- Catalpa's natural resistance to degradation could allow tree remnants to accumulate, giving the appearance of widespread mortality.

In areas with many dead catalpa trees, there is current evidence of all stages of tree health (i.e., some are healthy, some are dying, others have clearly been dead for some time). These trees can be seen in Photographs 4 through 8. It was discovered during the field survey that dead catalpa trees were also present off Site, as well as at the northern extreme of the Site (i.e., away from areas impacted by Site operations, Photograph 9). In addition, it was noted

that apparently robust catalpa saplings are growing from residue material on Site (Photograph 10). In areas on Site and off Site where dead trees were observed, significant inundation of soil was also observed (see Photograph 5). It is not clear whether the inundation is due to prolonged or episodic flooding of the area, but it is known that catalpa are facultative upland plants (i.e., they are found in upland habitats 70 percent to 99 percent of the time) (U.S. Department of Agriculture 2004). Further evidence of transitional conditions is the apparent succession toward water tolerant species, such as willow (*Salix* sp.), as shown in Photographs 7 and 8. It has been unclear whether the mortality of these trees was due to physical or chemical stressors. Furthermore, the actual length of time over which mortality occurred is unknown, but it is known that catalpa wood is very resistant to degradation. In fact, farmers introduced Northern Catalpa in order to produce large amounts of relatively lightweight timber for fence posts, since the wood is very resistant to rotting (Ohio Department of Natural Resources 2004). This resistance to degradation is likely contributing to the accumulation of tree remnants.

Aquatic Habitat

There are two primary drainage systems that receive and convey flow from the Site, as shown in Figure VII-4: the Eastern Drainage and Western Drainage. The Eastern and Western Drainages are described in the following subsections, including a description of flow direction as well as the on Site and off Site aquatic habitats associated with the drainages.

There is also one small aquatic feature that is not categorized as being part of the Eastern or Western Drainage, thus it is described very briefly here. This aquatic feature is a very small retention pond located immediately south of the manufacturing area (Figure VII-3). This pond has been identified as “intermittently exposed palustrine wetlands with unconsolidated materials in diked or impounded areas” on the National Wetland Inventory (NWI) Map for Hillsboro, Illinois (U.S. Fish & Wildlife Service, 1988). Railroad spurs create a narrow corridor where one would expect water movement to be constrained. There is no apparent outflow from the small pond, and inflow appears to be via overland runoff (channels were dry at the time of the July 2002, March 2004, and June 2004 visits). In July 2002, basking turtles were

observed in the east end of the pond, as well as dragonflies and frogs. Floating algal mats in the pond were also noted.

Eastern Drainage Area

The Eastern Drainage enters the Site from the north and drains the northeastern corner of the Site. Drainage from the northern wooded area (Figures VII-3 and VII-4) flows via an undefined channel/marshy area near the origination points (e.g., illustrated in Photograph 5), and flows via a more defined natural channel near the stormwater ponds and the eastern boundary of the Site. The Eastern Drainage also conveys outflow from two man-made stormwater retention ponds. The stormwater retention ponds receive drainage from the manufacturing area, as seen on Figures VII-3 and VII-4. The tributaries comprising the Eastern Drainage converge near the eastern Site boundary and flow east northeast approximately 1/2 mile to Lake Hillsboro (Figures VII-3 and VII-4).

Flow via the stormwater retention ponds was previously managed via an IEPA National Pollutant Discharge Elimination System (NPDES) Permit. In May 2003, the IEPA terminated the Site's NPDES Permit. The permit was terminated because, according to the IEPA's May 23, 2003 Public Notice Fact Sheet of Intent to Terminate NPDES Permit No. IL0074519, "...the facility has closed, all industrial activity has ceased, and the discharges have ceased."

On Site Eastern Drainage Aquatic Habitat

Aquatic habitat in the on Site portion of the Eastern Drainage is very limited, even dry at times (such as during the July 2002 field survey and during sampling in 2003). Although on Site areas of the Eastern Drainage were observed to be inundated during the June and October 2004 field surveys (as seen in Photographs 5, 6, and 7), even when wet the limited aquatic habitat is not sufficient to support fish, or piscivorous (fish eating) species (see the discussion of location ED-12 in Appendix A-6). Habitat in the stormwater retention ponds is also limited, as the ponds are composed of a small concrete settlement structure and a two-cell, clay-lined retention pond installed in 2001. Water levels in the stormwater retention ponds have been observed to fluctuate between one foot (July 2002) and several feet (March, June, and October 2004). Algal blooms and frogs were observed in the ponds during

the July 2002 and two 2004 field surveys; however, the stormwater retention ponds do not provide suitable habitat for fish or piscivorous wildlife.

Off Site Eastern Drainage Aquatic Habitat

Aquatic habitat in the off Site Eastern Drainage (Photograph 13) is of slightly higher quality than habitat on Site because there are small pools and unaltered channels that may provide more stable and lasting aquatic habitat (though these pools are not perennial in the vicinity of the Site, it is likely that perennial pools exist as flow approaches Lake Hillsboro; see Appendix A-6). Very small fish (centrarchids), damselflies, crayfish burrows, and sunfish were observed in a small pool in the vicinity of Lake Hillsboro in July 2002. Lake Hillsboro, a manmade reservoir approximately 1/2-mile east of the Site (Photograph 14) provides diverse aquatic habitat. Fish and piscivorous wildlife are likely to be present in the lake.

Western Drainage Area

The Western Drainage originates on Site near the manufacturing area, flows in a southwesterly direction into a stormwater retention pond, and ultimately flows off Site via an outfall to an unnamed drainage (Figure VII-3 and VII-4). The stormwater retention pond outfall was previously managed under the same NPDES permit mentioned for the Eastern Drainage (cancellation of the permit in 2003 applied to both outfalls). Flow from the stormwater pond merges with flow from another unnamed drainage (this one south of the Site), and this joined drainage feature flows westerly until its confluence with an unnamed tributary that ultimately flows northward toward Middle Fork Shoal Creek (approximately one mile from the Site).

On Site Western Drainage Aquatic Habitat

The origin of the on Site Western Drainage is a small ditch in the western portion of the Site (Photograph 3). The Western Drainage flows through a small man-made wetland area (Photograph 21) dominated by common reeds (*Phragmites australis*) and juncus (*Juncus acuminatus*) to its accumulation in the stormwater retention pond. On Site Western Drainage habitat in the stormwater retention pond is perennial and sufficient to support aquatic wildlife, such as small fish, turtles, frogs, and piscivorous wildlife (Photographs 15 through 21). The pond is mapped as “intermittently exposed palustrine wetlands with unconsolidated materials in diked or impounded

areas" on the USFWS NWI Maps (USFWS 1988). Albeit limited in size, the approximately one acre stormwater retention pond provides the most significant aquatic habitat on Site because the presence of water is perennial and vegetative cover is available (both macrophytes and adjacent willow canopy). However, this aquatic feature is man made. Water enters the pond via a swale and residue-covered berms form the pond basin (to the north, west and south). Residue material, broken concrete, and other items currently constrict the outfall.

In March and June 2004, no flow from the outfall of the pond to the stream was observed, but seepage from the berm was noted, as well as evidence of overland flow (dry at the time of the July 2002 Site visit) to the stream. Flow from the pond to the stream was noted in October 2004, which followed a significant rainfall event. Photographs 15 through 19 show the pond at various times and seasons. Floating algal mats and pondweed were observed in the pond, and this vegetation provides habitat cover for fish, aquatic organisms, and amphibians. Dragonflies were observed in this area in July, and numerous fish (including fathead minnows [*Pimephales promelas*], common shiner [*Luxilus cornutus*], and green sunfish [*Lemomis cyanellus*]) were seen in the pond. Two green herons (*Butorides virescens*) were observed feeding at its upstream end. Aside from the stormwater pond, very little aquatic habitat exists within the on Site Western Drainage area (see the discussion of location WD-9 in Appendix A-6).

Off Site Western Drainage Habitat

Water flows off Site via an unnamed drainage to its confluence with an unnamed tributary, ultimately flowing due north via the unnamed tributary to Middle Fork Shoal Creek (approximately 1 mile from the Site). Immediately off Site in the Western Drainage, habitat is again very limited due to high and low water cycles (Photographs 20 and 22). For example, the drainage south of the Site (Figure VII-3) was dry at the time of the July 2002 visit, but there was very shallow flowing water in March, June, and October 2004. The off Site Western Drainage (south of the Site) also appeared to have limited habitat due to heavy siltation (e.g., Photograph 23), with possible contributions from an adjacent facility (a concrete plant) to the south. Nevertheless, in March 2004, filamentous algae in this habitat were widespread (Photograph 23), but no other aquatic life was noted. In June

2004, small fish and aquatic insects were observed in this drainage feature. Discarded plywood and other debris were also observed.

As drainage flows westerly away from the Site, the unnamed drainage passes through residential areas until its confluence with the unnamed tributary. The habitat in the unnamed drainage is very limited and does not support fish habitat on a perennial basis (Photographs 24). Some habitat qualities increase as flow volume increases in the unnamed tributary that flows north to Middle Fork Shoal Creek (Figures VII-3 and VII-4). However, even in the higher volume flow locations off Site in the Western Drainage (i.e., in the unnamed tributary), the aquatic habitat is limited (Photograph 25). These areas also support greater canopy cover and riparian habitat (which provides a buffer to the aquatic habitat). For example, nettles (*Urtica dioica*), common reeds (*P. australis*), and juncus (*Juncus acuminatus*) were observed in the creek floodplain. Wildlife observations included whitetail deer tracks, raccoon tracks, turtle burrows, frogs, crayfish holes, and an eastern box turtle in a creek burrow.

Off Site Adjacent Land Use

The land use context in which a Site is located is relevant in an ERA for understanding potential influences of a Site relative to other stressors. The land use adjacent to the Site is also characterized by intensive human land use, with a number of commercial/industrial facilities in the immediate vicinity (Figure VII-3):

- North: Small facility, Hayes Abrasives; golf course; agricultural fields
- South: Small commercial/industrial facilities, including University of Illinois Extension office; Fuller Brothers Construction/Ready Mix; Hixson Lumber; Hillsboro Rental; Vogel Plumbing
- East: Industrial Drive; an asphalt company; a railroad corridor; former Hillsboro Glass Company facility (now a steel warehouse); and a densely wooded drainage corridor that leads to Lake Hillsboro
- West: Undeveloped land and a residential area containing single- and multi-family dwellings

In addition to the intensive human use just discussed, natural areas that form a habitat mosaic must also be considered. A close evaluation of Figure VII-3

shows aerial imagery of the area surrounding the Site (i.e., areas outside the habitat characterization used for the Site). As can be seen on Figure VII-3, and was observed during the field surveys in 2002 and 2004, the aquatic and terrestrial habitat on Site is part of a much larger landscape mosaic. For example, along the off Site Eastern Drainage, dense riparian woodlands leading to Lake Hillsboro can be seen in the aerial imagery. Similarly, to the northwest of the Site, woodlands can be seen along the off Site Western Drainage. Also, though not shown on Figure VII-3, the Bremer Sanctuary, located just 1 mile north of Hillsboro, provides more than 200 acres of oak-hickory upland and 40 acres of grasslands.

b. Identification of Constituents Detected and Classification of Sediments

This section presents a summary of constituents detected in surface water, sediment, and soil. In addition, the classification of sediments is provided for sieved sediments using IEPA's Evaluation of Illinois Sieved Stream Sediment Data (IEPA, 1997) and unsieved sediments in Illinois, using data developed by Kelly and Hite (1984).

i. Occurrence of Constituents Detected

This section discusses the constituents detected in the on Site and off Site surface water, on Site and off Site sediment, and on Site soil. The analytical data obtained during the RI (ENVIRON 2003a&b) were used to identify constituents on Site and off Site. The analytical data for each medium is presented in Appendix B, with sample locations identified on Figures VII-5a, VII-5b, and VII-5c, for surface water, sediment, and soil (respectively). The data were compiled into on Site and off Site groupings as part of the SLERA evaluation, as indicated in Appendix C, Table C-1, with on Site and off Site summaries provided by medium in Appendix C, Tables C-2 through C-4. The following summaries of the constituents that were detected are provided in Appendix C:

- Table C-2a: Occurrence of Constituents in Surface Water (On Site)
- Table C-2b: Occurrence of Constituents in Surface Water (Off Site)
- Table C-3a: Occurrence of Constituents in Sediment (On Site)
- Table C-3b: Occurrence of Constituents in Sediment (Off Site)
- Table C-4: Occurrence of Constituents in Surface Soil (On Site)

In keeping with the conservative nature of a SLERA, maximum detected chemical concentrations identified from Tables C-2 through C-4 are used in this

SLERA (USEPA, 2000a, 2001a). The tables presented in Appendix C also identify the constituents detected, the frequency of detection, the range of sample quantitation limits, the range of detected concentrations, the 95 percent upper confidence limits (UCLs), and exposure point concentrations (EPCs). The EPC is the lesser of the maximum detected concentration or the UCL for each constituent. The UCLs were calculated assuming lognormal distributions (Gilbert 1987).

The surface water and sediment sampling program involved characterization of conditions on Site and off Site, as identified on Figures VII-5a and VII-5b, respectively. Inorganic constituents (metals and sulfate) as well as volatile organic compounds (VOCs) were detected in each medium, as follows:

- On Site Surface Water (Table C-2a): 15 inorganic constituents, 2 VOCs
- Off Site Surface Water (Table C-2b): 23 inorganic constituents
- On Site Sediment (Table C-3a): 21 inorganic constituents, 6 VOCs
- Off Site Sediment (Table C-3b): 21 inorganic constituents

The on-Site soil sampling program involved collection of surface soil samples (i.e., samples from approximately 0-2 feet below ground surface [bgs]) and samples from 0-2 feet below residue materials (Figure VII-5c). On Site soil X-ray fluorescence (XRF) screening results were used to select soil samples to be retained for target metals analysis. As indicated on Table C-4, 23 metals were detected in soil.

ii. Classification of Sediments

This section presents the classification of on Site and off Site sediments using sieved and unsieved classification categories available for Illinois (IEPA 1997; Kelly and Hite 1984). This analysis is provided at USEPA request. The intent of this classification is to have a means of identifying sediments that contain inorganic constituents at concentrations that are elevated above typical levels in Illinois, and to compare recent data to historical unsieved data to assess trends. Classification levels provided for sieved and unsieved sediments are based on physical size and chemical characterization only, and should not be inferred to reflect chemical toxicity (concentrations reflective of toxicological levels are discussed in greater detail in Section VII.B.2 of this SLERA). IEPA's *Evaluation of Illinois Sieved Stream Sediment Data; 1982-1995* (1997) is used for this evaluation (Table C-5a). The IEPA document describes a classification of sieved sediment data (e.g., non-elevated, elevated, and highly elevated) based on a large

dataset of sediments collected throughout Illinois. Similar classification levels for unsieved sediments in Illinois, developed by Kelly and Hite (1984), is also included in Table C-5a. The Kelly and Hite unsieved values are most appropriate for comparison, because the sediment samples collected for the Eagle Zinc Site were unsieved. The comparisons of on Site and off Site data to both sieved and unsieved classification levels is provided on Tables C-5b (sieved) and C-5c (unsieved).

c. Description of Constituent Fate and Transport Pathways

After the environmental setting and the constituents are described, the next step in the screening-level problem formulation is consideration of the fate and transport pathways that might allow a constituent to interact with an organism. Knowledge about the potential fate and transport pathways of the constituents detected is vital to understanding which chemicals and receptors are associated with complete exposure pathways. This is because the pathway and route of exposure may have a strong influence on the ecological effect of a constituent. This information is ultimately used to develop the conceptual Site model (CSM).

Potential migration pathways at the Site were evaluated in the Phase 2 Technical Memorandum (ENVIRON 2003b). With the exception of the limited area where chlorinated volatile organic compounds were detected in sediments and surface water, the constituents in Site media are all metals. The concentration and distribution of these metals in environmental media on and in the vicinity of the Site could be (and/or could historically have been) affected by one or more of the following general mechanisms, as illustrated in Figure VII-6a and Figure VII-6b:

- Suspension and transport of constituents in air
- Suspension and transport of constituents in surface water runoff
- Leaching of Constituents from residue material to underlying soil and ground water
- Migration of constituents in ground water
- Ground water-to-surface water transport of constituents

A detailed evaluation of available historical data for the Site, including the off Site soil data collected by IEPA in 1993 as part of the CERCLA Expanded Site Inspection (ESI), was performed to evaluate these potential transport pathways. As discussed in Section IV.B.6, available data and information concerning the residue material does not suggest that air deposition has impacted nearby off Site areas.

The predominant topographic slope of the Site is southerly, and the southwestern stormwater pond receives a large proportion of the Site's stormwater runoff (i.e., the Western Drainage, Figure VII-6a). Storm water intermittently discharges westward from this pond to an unnamed drainage swale, which in turn discharges to an unnamed tributary of Middle Fork Shoal Creek. The eastern stormwater retention system discharges to a drainage swale that channels the stormwater from the Site to the east and ultimately into Lake Hillsboro, approximately 1/2-mile east of the Site (i.e., the Eastern Drainage, Figure VII-6b). As a result, surface water impact could occur in both the Western Drainage and the Eastern Drainages due to constituents being carried off Site in stormwater runoff. However, it should be noted that stormwater discharge from both the Western and Eastern Drainages was managed via NPDES permitted outfalls prior to permit cancellation in May 2003.

Based on ground water contour maps previously constructed for the Site (ENVIRON 2003b), shallow ground water in the western and southwestern portions of the Site flows southward/southwestward (towards and parallel to the Western Drainage Area), and shallow ground water in the eastern portion of the Site flows eastward/southeastward (towards and parallel to the Eastern Drainage Area). Therefore, discharge of ground water into surface water bodies proximate to the Site could also be a source of constituents to off Site surface water bodies. On Site areas within the Eastern Drainage Area include large non-operational areas (e.g., the Northern Area and areas east of the Manufacturing Area) and lack significant source areas, such as residue materials. The fact that no dissolved metals were detected above applicable ground water screening concentrations in these wells (ENVIRON 2003b) reflects the known lack of source areas that are impacting ground water in the areas east of the Site. Thus, the available data indicate that ground water flow to the Eastern Drainageway and Lake Hillsboro is not a significant transport pathway. Based on the limited off Site extent of ground water impacted by dissolved metals concentrations to the southwest of the Site, it is similarly concluded that ground water discharge is not a significant pathway for the off Site transport of constituents to the Western Drainage.

d. Description of Constituent Mechanisms of Ecotoxicity

The mechanisms of ecotoxicity for constituents vary depending on a wide range of factors, such as constituent concentration, the wildlife receptor species exposed, the exposure route (e.g., ingestion or direct contact), and physical factors (e.g., pH, temperature, oxygen levels). Some of the effects that could be observed in wildlife are mortality and reduced reproductive ability, decreased fertility, decreased offspring survival, alteration of immune and behavioral function, decreased hatching success of

eggs/larvae, and retarded growth (Sample, et al. 1996; USEPA 2002). The remainder of this section discusses mechanisms of ecotoxicity for the classes of compounds detected at the Site. These descriptions of constituent mechanisms of toxicity are presented without consideration of constituent concentrations, as the descriptions seek to convey an understanding of possible effects rather than describe the concentrations at which these effects might occur. More detail will be provided, as necessary for specific comments in the BERA (Step 3a).

i. Inorganic Constituents/Metals

The potential adverse impacts on aquatic wildlife from trace metals (such as arsenic, barium, beryllium, chromium, copper, lead, and zinc) are well understood (Newman, 1998). Chromium, copper, and zinc are essential for healthy enzyme function, and some organisms cannot survive without these metals. However, these naturally occurring constituents may cause adverse effects when exposure occurs at concentrations that significantly exceed background concentrations. The toxicity and effects of trace metals may be greatly influenced by pH, hardness, and organic carbon content of the water in which they occur (Leland and Kuwabara 1985).

Imbalances in the essential trace metals may cause a decrease in photosynthetic ability, poor spawning/hatching success, teratogenesis, susceptibility to predation and disease, reduced growth, mortality, histopathological changes, organ dysfunction of the liver or kidneys, neurological defects, changes in respiration and osmoregulation, and anemia. Some metals may bioaccumulate, but this mechanism is thought to be of minor ecological concern. Because these constituents are naturally occurring, many organisms have a capacity (albeit limited) to biotransform and/or eliminate naturally occurring inorganics (Newman 1998; Leland and Kuwabara 1985).

ii. Volatile Organic Compounds

Volatile organic compounds (VOCs) tend to attenuate rapidly in surface soil due to their inherent volatility. Although the effects of VOCs on wildlife are not well understood, there have been extensive studies of the effects of VOCs under laboratory conditions. In laboratory test organisms, inhaled VOCs are typically metabolized in the liver, which may cause liver damage or the release of more toxic secondary metabolites. The VOC or its metabolites may also cause neurological damage, and many are mutagenic or carcinogenic. Additionally, some VOCs are fetotoxic and or teratogenic (USEPA, 2003a).

e. Description of Potentially Exposed Receptors

The identification of the categories of receptors most likely affected helps focus the SLERA. Section VII.B.1.a and Appendix A provide descriptions of the terrestrial and aquatic habitat and wildlife on Site and off Site. This information was used to develop the CSM illustrated in Figure VII-7. As illustrated on the CSM, terrestrial and aquatic wildlife and plants could be exposed to constituents from the Site.

f. Identification of Potentially Complete Exposure Pathways

A complete exposure pathway is one in which constituents can be traced or expected to travel from the source to a receptor that can be affected by the constituents (USEPA 1997). Therefore, a chemical, its release and migration from the source, a receptor, and the mechanisms of toxicity of that chemical must be demonstrated before a complete exposure pathway can be identified. The components of an exposure pathway (the constituents, their migration, their effects, and the receptors) have already been discussed. The table below and Figure VII-7 illustrate the potentially complete exposure pathways that will be evaluated in the SLERA.

Identification of Potentially Complete Exposure Pathways	
Organism	Possible Exposure Routes
Aquatic biota	Ingestion, respiration, surface contact, food web
Avian/mammalian piscivores	Ingestion, surface contact, food web
Terrestrial avian/mammalian wildlife	Ingestion, surface contact, food web

g. Identification of Generic Assessment and Measurement Endpoints

Assessment endpoints are the explicit expression of the ecological values to be protected (USEPA 1997). The selection of assessment endpoints depends on knowledge of the receiving environment, knowledge about the constituents released (including ecotoxicological properties and concentrations that cause adverse impacts), and understanding of the values that will drive risk management decision-making (Suter, et al. 1995). For the SLERA, assessment endpoints are any adverse effects on ecological receptors, where receptors are plant and animal populations and communities, habitats, and sensitive environments. Many of the ecotoxicity screening values are based on generic assessment endpoints (e.g., protection of aquatic communities from changes in structure or function) and are assumed to be widely applicable to Sites around the United States” (USEPA 1997).

Since direct measurement of assessment endpoints is often difficult (or impossible), surrogate endpoints (called measurement endpoints) are used to provide the

information necessary to evaluate whether the values associated with the assessment endpoint are being protected. A measurement endpoint is a measurable ecological characteristic and or response to a stressor (USEPA 1998). Measurement endpoints are also referred to as measures of potential effect (USEPA 1998). Measurement endpoints, such as mortality, reproductive effects, and reduced growth are considered for the SLERA but are not directly measured. These measurement endpoints are indirectly evaluated in the SLERA through the use of hazard quotients (HQs). An HQ is the ratio of a constituent concentration to an associated ecotoxicity screening value. The measurement endpoints/HQs for the Site are discussed further in Section VII.B.2.

Surrogate wildlife receptors must also be identified in order to perform necessary SLERA exposure estimates and risk calculations. These species are generally selected based on consideration of presence at the Site as well as known or suspected sensitivity and exposure to the constituents of potential concern (USEPA 1997).

The SLERA assessment endpoints, measurement endpoints, and surrogate receptors (where appropriate) for the Site are identified as follows:

SLERA Identification of Generic Assessment and Measurement Endpoints			
Ecological Receptor	Assessment Endpoint	Surrogate Receptors	Measurement Endpoint
Aquatic biota (On Site and Off Site)	Maintenance of diverse and abundant aquatic communities	Water column and benthic communities	Comparison of maximum on Site and off Site detected concentrations to surface water and sediment ecotoxicity screening values
Avian and mammalian piscivorous wildlife (On Site and Off Site)	Survival and reproductive ability of populations	Mink, heron	Comparison of maximum on Site and off Site surface water chemical concentrations to piscivorous wildlife ingestion-based NOAELs
Terrestrial mammals and birds (On Site)	Survival and reproductive ability of populations	Deer mouse, American robin, red-tailed hawk	Food web modeling using maximum on Site soil concentrations with comparison to ingestion-based NOAELs
NOAELs	No Observed Adverse Effects Levels		

2. Screening-Level Ecological Effects Evaluation

The screening-level ecological effects evaluation involves the identification of appropriate ecotoxicity screening values (ESVs) for each medium. ESVs are chemical concentrations in environmental media below which there is negligible risk to receptors exposed to those media (USEPA 2000a). ESVs are available from a broad range of federal

and state sources, one or more of which may be applicable for any given Site. Further, ESVs for all media and all receptors may not be available from each source; thus, consideration of a range of sources provides greater opportunity for identification of ESVs. The ESVs used in this SLERA are described below:

a. SLERA Surface Water and Sediment Ecotoxicity Screening Values (Direct Toxicity)

The surface water ESVs are summarized on Table VII-1a. They are based on the following hierarchy for the designation of a single ESV for use in the SLERA. Criteria summarized on this table are chronic values (when available) as these values represent long-term exposures and are generally more conservative than acute values. It has been stated that the National Recommended Water Quality Criteria (NRWQC) (USEPA 2002a; 2002b), and similar criteria such as the Illinois Water Pollution Control Board (IWPC) Water Quality Criteria (2002), are intended to protect “95 percent of the species 95 percent of the time.” However, these criteria are not available for every constituent. As such, alternative sources of criteria, such as the Secondary Chronic Values (Suter and Tsao 1996) are used (it should be noted that “primary” criteria are considered the NRWQC). Secondary chronic values are considered less rigorous than the NRWQC and IWQC because fewer toxicity studies representing fewer species are used in the derivation (Suter and Tsao 1996). USEPA Region 4 (2000b) and USEPA Region 5 (2003b) use a combination of criteria from a variety of sources, including the NRWQC. For this SLERA, ESVs were selected using the hierarchy presented in the bulleted list below:

- IWPC Water Quality Criteria (2002a, 2002b)
- USEPA NRWQC (2002)
- Suter and Tsao Secondary Chronic Values (1996)
- USEPA Region IV (2000c)
- USEPA Region V (2003)

The sediment ESVs are summarized on Table VII-2. The criteria summarized on this table are guidelines derived to protect organisms that live and feed in direct contact with sediment (i.e., sediment benthos). Conservative values, such as threshold effects levels (TELs) were selected in place of values such as probable effects levels (PELs) or severe effects levels (SELs). A range of ESVs available from a variety of sources is shown on Table VII-2. The ESVs used in this SLERA were selected from the hierarchy presented in the bulleted list below:

- USEPA Region IV (2000b)
- USEPA Region V (2003b)
- National Oceanic and Atmospheric Administration (NOAA 1999)
- United States Geologic Survey (Ingersoll et al. 2000)
- Ontario Ministry of the Environment (OME 1993)

b. SLERA Water and Dietary Prey Ecotoxicity Screening Values for Piscivorous Wildlife

Piscivorous wildlife water dietary prey ESVs are summarized on Table VII-3, with a more complete documentation of the screening values presented in Appendix D, Table D-1a. The ESVs used to evaluate exposures to piscivorous wildlife in this SLERA are the most conservative NOAEL-based screening values for either the mink or great blue heron. The piscivorous wildlife NOAEL-based ESVs were developed by Sample et al. (1996) using an equation that allows the comparison of detected water concentrations to the ESVs that are reflective of COPC intake via both water and dietary prey. These NOAELs used in the ESV derivation are based on chronic exposures to piscivorous wildlife, and reflect values where diminished survival or diminished reproductive capacity would not be expected (i.e., no observable adverse effects).

c. SLERA Ecotoxicity Screening Values for Soil Food Web Exposures to Terrestrial Wildlife

The terrestrial mammalian and avian NOAELs are also summarized on Table VII-3, with a more complete documentation presented in Appendix D (Table D-1b and D-1c, for mammalian and avian receptors, respectively). The SLERA avian and mammalian NOAELs are based on the compilation of Sample et al. (1996). Similar to that described for piscivorous wildlife, these NOAELs are based on chronic exposures to wildlife, and reflect values where diminished survival or diminished reproductive capacity would not be expected.

These NOAELs are referred to as ESVs in this report because they are presented in a SLERA screening context. However, unlike the piscivorous wildlife NOAELs, which involve direct comparison of detected water concentrations to the piscivorous wildlife NOAELs, the terrestrial wildlife NOAELs are based on species-specific food web modeling calculations. These modeling calculations are discussed further in Section VII.C. of this SLERA. Further, mammalian NOAELs from Sample, et al., (1996) required mathematical extrapolation to provide estimates of deer mouse NOAELs (derived from data on laboratory test species). This mathematical formula is described in Appendix D, Tables D-1b and D-2a. Per Sample et al., avian NOAELs do not require a similar mathematical extrapolation. The avian NOAELs are the same regardless of

avian species (i.e., the same NOAEL values are used for both the American robin and the red-tailed hawk, even if based on a mallard duck study, as identified in Appendix D, Table D-1c.

C. Step 2: Screening-Level Exposure Estimate and Risk Calculation

The screening-level exposure assessment is comprised of the identification of exposure estimates, risk calculations, and the evaluation of uncertainties (USEPA, 1997; 2001a). These form lines of evidence to support the scientific management decision point (SMDP) at the conclusion of the SLERA.

1. Identification of Screening-Level Exposure Estimates

This section describes the exposure estimate assumptions used in the SLERA for aquatic wildlife exposed directly to surface water and sediment (described in Section VII. C.1.a.), piscivorous wildlife exposures via ingestion of surface water and dietary prey (described in Section VII. C.1.b.), and terrestrial wildlife exposures via food web exposures (described in Section VII. C.1.c.).

a. Screening-Level Exposure Estimates for Aquatic Wildlife: Surface Water and Sediment (Direct Toxicity)

The maximum concentrations detected in the on Site and off Site surface water and sediment samples were used for this SLERA as part of the evaluation of potential direct toxicity. These concentrations are summarized on the following tables, for the following media groupings:

- Table VII-4a: On Site Surface Water
- Table VII-4b: Off Site Surface Water
- Table VII-5a: On Site Sediment
- Table VII-5b: Off Site Sediment

b. Screening-Level Water and Dietary Prey Exposure Estimates to Piscivorous Wildlife

The maximum concentrations detected in the on Site and off Site surface water samples were used for this SLERA as part of the evaluation of potential water and dietary toxicity for piscivorous wildlife. These concentrations are summarized on the following tables, for the following media groupings:

- Table VII-6a: On Site Surface Water
- Table VII-6b: Off Site Surface Water

c. Screening-Level Estimates for Food Web Exposures to Terrestrial Wildlife

Food web exposure modeling involves many more inputs than the direct contact and piscivorous wildlife exposure estimates. The estimate of food web exposures to terrestrial wildlife involves a variety of factors, such as species-specific food web modeling intake formulae, medium-specific concentrations (i.e., soil and water concentrations) species-specific exposure parameters, and bioaccumulation/bioconcentration factors for the estimation of chemical concentrations in dietary prey. This section identifies the exposure parameter values used for the terrestrial food web exposure modeling. Per discussions with USEPA, only those constituents identified as bioaccumulative compounds in USEPA's Bioaccumulation Testing and Interpretation of Sediment Quality Assessment (USEPA 2000c) are included in this evaluation. The bioaccumulative constituents detected in the soil and water at the Site are:

- | | |
|------------|------------|
| • Arsenic | • Mercury |
| • Cadmium | • Nickel |
| • Chromium | • Selenium |
| • Copper | • Silver |
| • Lead | • Zinc |

i. Species-Specific Food Web Modeling Formulae

Food web modeling involves consideration of chemical parameters such as soil and water concentrations, as well as consideration of species-specific food and water intake rates, normalized to a species body weight. An overview of the species-specific food web modeling approaches and equations is provided in Appendix D, for the following receptors:

- Table D-2a: Deer Mouse
- Table D-2b: American Robin
- Table D-2c: Red-Tailed Hawk

ii. Medium-Specific Concentrations

The maximum concentrations detected in the on Site soil and surface water samples were used for this SLERA as part of the evaluation of potential water and food web toxicity for terrestrial mammalian and avian wildlife. These concentrations are summarized on the following tables, for the following receptors:

- Table VII-7a: Deer Mouse
- Table VII-7b: American Robin
- Table VII-7c: Red-Tailed Hawk

iii. Species-Specific Exposure Parameters

Species-specific exposure parameters that are used in the SLERA food web exposure modeling are conservative values designed to provide maximum estimates of exposure (USEPA, 1997). For example, a dietary makeup that maximizes potential dietary exposure is selected for the SLERA, while a more realistic dietary makeup would be used for subsequent evaluation (if needed). For the SLERA, a conservative low body weight is estimated for use in the ingestion intake calculations, while an elevated body weight is used in the allometric equations estimating food and water ingestion rates (USEPA 1993; Sample and Suter 1994). In addition, Site foraging frequency is assumed to be a value of 1, assuming that the species spends 100 percent of its time in the portion of the Site with maximum detected concentrations, even species with a large home range. Similarly, species that migrate are assumed to spend 100 percent of their time at the Site, even when it is known that they migrate for a portion of the year. These conservative default assumptions are consistent with a SLERA approach and are summarized in Appendix D, for the following receptors:

- Table D-3a: Deer Mouse
- Table D-3b: American Robin
- Table D-3c: Red-Tailed Hawk

iv. Bioaccumulation Factors and Bioconcentration Factors

Bioaccumulation factors and bioconcentration factors are used to estimate tissue concentrations in food web modeling (Sample et al. 1998a&b; Bechtel 1998). Chemical concentrations in soil are multiplied by bioconcentration factors to estimate tissue concentrations for invertebrates and vegetation, while bioaccumulation factors are used to estimate uptake into mammals. The

mathematical formulae presented in Appendix D-2a, D-2b, and D-2c illustrate this approach (though the terms used in these formulae are more generally denoted as “uptake factors”). While both 90th percentile and median bioaccumulation and bioconcentration factors are summarized in Appendix D-4, the more conservative 90th percentile values are used for the SLERA. These values were compiled from the following sources:

- Sample et al. (1998a)
- Sample et al. (1998b)
- Bechtel (1998)

2. Screening-Level Risk Calculations

Risks are calculated in this SLERA by dividing conservative chemical-specific exposure estimates (described in Section VII. C.1.) by conservative chemical-specific ESVs (described in Section VII. B.2.). These unitless chemical-specific ratios are referred to as hazard quotients (HQs). HQs are considered a surrogate for the assessment endpoint, which is the protection of wildlife populations and communities at the Site (as described in Section VII. B.1.e.). An HQ equal to or less than a value of 1 (to one significant figure) indicates that adverse impacts to wildlife are considered unlikely (USEPA 1997; 2000a). An HQ greater than 1 is an indication that further evaluation may be necessary to evaluate the potential for adverse impacts to wildlife. Therefore, the constituents with HQs greater than 1 are carried forward as constituents of potential concern (COPCs) into a BERA. The remainder of this section describes SLERA risk calculations for (1) direct toxicity to aquatic organisms (surface water and sediment), (2) dietary and water intake to piscivorous wildlife, and (3) food web exposures to terrestrial wildlife.

a. SLERA Risk Calculations for Direct Toxicity to Aquatic Wildlife: Surface Water and Sediment

The risk calculations for aquatic wildlife are presented for each medium as follows: Table VII-4a (On Site Surface Water), Table VII-4b (Off Site Surface Water), Table VII-5a (On Site Sediment), and Table VII-5b (Off Site Sediment). Constituents with HQs greater than a value of 1 are summarized below.

Direct Toxicity HQs Greater Than 1				
Constituent	Surface Water		Sediment	
	On Site HQ (Table VII-4a)	Off Site HQ (Table VII-4b)	On Site HQ (Table VII-5a)	Off Site HQ (Table VII-5b)
Aluminum		20		
Arsenic				3
Barium	10	20		
Cadmium	90	10	600	100
Copper			3	20
Iron		3		2
Lead			8	90
Manganese	3	5		2
Mercury			10	10
Nickel	2		2	2
Zinc	400	400	100	200
Acetone			5	

Blank cells indicate that the HQ was less than or equal to 1, the constituent was not detected, or there was no available ecological screening value.

Constituents with HQs greater than 1 will be carried forward into Step 3a of the BERA for further evaluation of potential impacts to aquatic wildlife via direct contact. Step 3a of the BERA will focus on these constituents in the data groupings where elevated HQs were identified (e.g., zinc will be evaluated in on Site and off Site surface water and sediment, while arsenic will only be evaluated in off Site sediment). In addition, constituents for which ecotoxicity screening values were not available for a medium will also be carried forward as COPCs in that medium in Step 3a of the BERA. These constituents are summarized below by medium:

- Surface water – Calcium, magnesium, potassium, sodium, and sulfate
- Sediment – Aluminum, barium, beryllium, calcium, magnesium, potassium, selenium, sodium, vanadium, 2-butanone, and cis-1,2-dichloroethene

b. SLERA Risk Calculations for Piscivorous Wildlife – Water and Dietary Prey

The risk calculations for piscivorous wildlife for on Site and off Site piscivorous wildlife surface water/dietary prey exposures are presented in Table VII-6a and VII-6b, respectively. Constituents with HQs greater than a value of 1 are summarized below.

Piscivorous Wildlife HQs Greater Than 1		
Constituent	On Site HQ (Table VII-6a)	Off Site HQ (Table VII-6b)
Aluminum		60
Cadmium	500	80
Mercury		20
Selenium		5
Zinc	300	300

Blank cells indicate that the HQ was less than or equal to 1 or the constituent was not detected.

Constituents with HQs greater than 1 will be carried forward into Step 3a of the BERA for further evaluation of potential impacts to piscivorous wildlife via water and dietary intake. In addition, the following constituents for which piscivorous wildlife ecotoxicity screening values were not available will also be carried forward as COPCs in Step 3a of the BERA:

- Barium, calcium, cobalt, iron, magnesium, manganese, potassium, silver, sodium, sulfate, vanadium, cis-1,2-dichloroethene, trichloroethylene

c. SLERA Risk Calculations for Terrestrial Wildlife: Soil Food Web Exposures

Risk calculations for piscivorous wildlife are presented in Table VII-7a, VII-7b, and VII-7c, for deer mouse, American robin, and red-tailed hawk food web risk calculations, respectively. Constituents with HQs greater than a value of 1 are summarized below

Terrestrial Wildlife HQs Greater Than 1			
Constituent	Deer Mouse (Table VII-7a)	American Robin (Table VII-7b)	Red-Tailed Hawk (Table VII-7c)
Arsenic	20		
Cadmium	300	600	30
Chromium		30	
Lead	2	10	
Mercury		3	
Nickel			
Selenium	2		
Zinc	70	2,000	200

Note: Blank cells indicate that the HQ was less than or equal to 1

Constituents with HQs greater than 1 will be carried forward into Step 3a of the BERA on a receptor-specific basis. As can be seen on Tables VII-7a, VII-7b, and VII-7c, there are no constituents lacking NOAEL toxicity values.

3. Evaluation of Uncertainties

A SLERA is designed to provide conservative estimates of the potential risks that may exist for wildlife and, therefore, incorporates uncertainty in a precautionary manner.

Uncertainty in an ERA is “the imperfect knowledge concerning the present or future state of the system under consideration; a component of risk resulting from imperfect knowledge of the degree of hazard or of its spatial and temporal distribution” (USEPA, 1997). Uncertainties that may lead to either an overestimation or an underestimation of risk are associated with each stage of risk assessment. A summary of uncertainties that are associated with an ERA is provided in Table VII-8a.

One of the uncertainties identified on Table VII-8a is that there are occasions when analytical detection limits exceed ESVs. This can be due to instrument and method limitations and/or due to interference from unrelated chemicals (e.g., dilutions required to bring some other chemical within a calibration range). A comparison of the minimum and maximum detection limits to ESVs for the Eagle Zinc Site is provided in Tables VII-8b and VII-8c for constituents that were not detected in surface water and sediment, respectively. Though a few of the constituents had a maximum detection limit in surface water that exceeded an ESV, only three constituents had maximum detection limits that exceeded background (silver, with a maximum detection limit HQ of 3 for direct contact versus a background HQ of 0.2; mercury, 200 versus 30; and selenium, 10 versus 3). None of these constituents are site-related. No such exceedances were observed for the sediment.

4. Scientific Management Decision Point

SMDPs represent critical steps in the ecological risk assessment process where risk management decision-making occurs. The first SMDP in the ERA process may occur either at the end of Step 2 or Step 3a (USEPA, 2000a). The purpose of the flexibility of the first SMDP is so that additional evaluation of risks can occur and reporting can be streamlined into a single report. Generally, the following types of decisions are considered at this SMDP:

- Whether the available information is adequate to conclude that ecological risks are negligible and, therefore, there is no need for further action on the basis of ecological risk.
- Whether the available information is not adequate to make a decision at this point, and the ecological risk assessment process will continue.
- Whether the available information indicates a potential for adverse ecological effects, and a more thorough assessment or remediation is warranted.

Initial activities associated with a BERA are warranted (i.e., Step 3a) because the results of the screening-level risk calculation result in HQs greater than 1, and because this information is not adequate for decision-making. Therefore, as described in the following sections, the risk assessment will proceed to Step 3a for the receptors, media, and constituents described below, and the SMDP will occur at the conclusion of Step 3a:

a. Direct Toxicity for Aquatic Wildlife Exposed to Surface Water and Sediment

The following constituents will be further evaluated based on HQs greater than a value of 1 in the SLERA:

- On Site surface water – Barium, cadmium, manganese, nickel, and zinc
- Off Site surface water – Aluminum, barium, cadmium, iron, manganese, and zinc
- On Site sediment – Cadmium, copper, lead, mercury, nickel, zinc, and acetone
- Off Site sediment – Arsenic, cadmium, copper, iron, lead, manganese, mercury, nickel, and zinc

In addition, due to the lack of ESV's for a variety of constituents, these will be carried forward in the BERA for each media and data grouping in which they are detected:

- On Site and off Site surface water – Calcium, magnesium, potassium, sodium, and sulfate
- On Site and off Site sediment – Aluminum, barium, beryllium, calcium, magnesium, potassium, selenium, sodium, vanadium, 2-butanone, and cis-1,2-dichloroethene

b. Piscivorous Wildlife Exposed via Water and Dietary Prey

The following constituents will be further evaluated for potential risks to piscivorous wildlife based on HQs greater than a value of 1 in the SLERA:

- On Site surface water – Cadmium and zinc
- Off Site surface water – Aluminum, cadmium, mercury, selenium, and zinc

In addition, the following constituents also be carried forward as COPCs in Step 3a of the BERA due to the lack of piscivorous wildlife ESVs in the SLERA:

- Barium, calcium, cobalt, iron, magnesium, manganese, potassium, silver, sodium, sulfate, vanadium, cis-1,2-dichloroethene, trichloroethylene

c. Terrestrial Wildlife Exposed via the Food Web

The following constituents will be further evaluated for each wildlife receptor based on HQs greater than a value of 1 in the SLERA (and there are no constituents that will be carried forward into Step 3a of the BERA based on the lack of ESVs):

- Deer Mouse – Arsenic, cadmium, lead, nickel, selenium, and zinc
- American Robin – Cadmium, chromium, lead, mercury, and zinc
- Red-Tailed Hawk – Cadmium and Zinc

D. Step 3a: Baseline ERA Problem Formulation (Refinement of Step 2 Screening-Level ERA Exposure Estimates and Risk Calculations)

The BERA problem formulation is designed to more realistically identify the nature and extent of ecological risks in order to support informed environmental management decision-making (USEPA, 1997; 2000a). This is in contrast to the SLERA, which is designed to conservatively rule out further evaluation of chemicals and media that clearly do not pose significant ecological risk. The BERA problem formulation presented in this section is consistent with the RI/FS Work Plan (ENVIRON 2002a) and the following guidance:

- Ecological Risk Assessment Guidance for Superfund (USEPA, 1997)
- Guidelines for Ecological Risk Assessment (USEPA, 1998)
- Amended Guidance on Ecological Risk Assessment at Military Bases: Process Considerations, Timing of Activities, and Inclusion of Stakeholders (USEPA, 2000a)
- ECO-Update: Role of Screening-level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments (USEPA, 2001a)

The BERA problem formulation (Step 3) is the initial step in the BERA process, as illustrated on Figures VII-1 and VII-2. According to the USEPA (2000a):

“The Problem Formulation [i.e., Step 3] is commonly thought of in two parts: Step 3a and Step 3b. Step 3a serves to introduce information to refine the risk estimates from steps one and two. For the majority of Sites, ecological risk assessment activities will cease after completion of Step 3a. At many Sites, a single deliverable document consisting of the reporting of results from Steps 1, 2 and 3a may be submitted. At those Sites with greater ecological concerns, the

additional problem formulation is called Step 3b. It is very important at this stage to perform a 'reality check.' Sites that do not warrant further study should not be carried forward."

Step 3a of the ERA process (i.e., Problem Formulation) is an opportunity for iterative refinement of potential risks using methods similar to those used in Steps 1 and 2 (USEPA 2000a; 2001b), as illustrated on Figure VII-2. Specifically, COPCs identified in the SLERA may be eliminated from further consideration based on the refinement of certain assumptions, such as reasonable chemical exposure estimates, background reference location comparisons, and consideration of more realistic bioaccumulation potential. Step 3a is followed by a SMDP that involves the reporting of results to stakeholders for the Eagle Zinc Site. The components of Step 3a are presented in the remainder of this section.

Step 3a is a refinement of the Step 2 exposure estimates and risk characterization, focused only on the constituents and media that progress beyond the SLERA (i.e., those constituents and media specified in Section VII. C.4. of this report). Step 3a for the Eagle Zinc Site involves the following:

- **Section VII.D.1.: Refined Evaluation of Direct Toxicity Exposures and Risks for Aquatic Wildlife**
 - **Section VII.D.1.a.: Refinement of Direct Contact surface Water and Sediment COPCs**
 - **Section VII.D.1.b.: Refinement of Direct Contact Risk Calculations for Aquatic Wildlife**
 - **Section VII.D.1.c.: Overall Conclusions for Aquatic Wildlife**
- **Section VII.D.2.: Refined Evaluation of Water Dietary Exposures and Risks for Piscivorous Wildlife**
 - **Section VII.D.2.a.: Refinement of Piscivorous Water/Dietary COPCs**
 - **Section VII.D.2.b.: Refinement of Piscivorous Risk Calculations**
 - **Section VII.D.2.c.: Overall Conclusions for Piscivorous Wildlife**
- **Section VII.D.3.: Refined Evaluation of Food Web Exposures and Risks for Terrestrial Wildlife**
 - **Section VII.D.3.a.: Refinement of Terrestrial Food Web COPCs**
 - **Section VII.D.3.b.: Refinement of Terrestrial Wildlife Risk Calculations**
 - **Section VII.D.3.c.: Overall Conclusions for Terrestrial Wildlife**
- **Section VII.D.4.: Refined Uncertainties**
- **Section VII.D.5.: Scientific Management Decision Point**

1. Refined Evaluation of Direct Toxicity Exposures and Risks for Aquatic Wildlife

This section presents the refinement of direct contact surface water and sediment COPCs (Section VII. D.1.a.), the refinement of direct contact risk calculations for aquatic wildlife (Section VII. D.1.b.), and overall conclusions regarding risks to aquatic wildlife (Section VII. D.1.c.).

a. Refinement of Direct Contact Surface Water and Sediment COPCs

The refinement of the COPCs identified in the SLERA is necessary to help focus further risk assessment activities on the constituents that potentially pose the greatest risk to ecological receptors. USEPA guidance for this approach (USEPA, 1997; 2000a; 2001a) indicates that the refinement of COPCs streamlines the overall ERA process by using realistic criteria to focus the risk assessment. It is intended as an “incremental iteration of exposure, effects, and risk characterization” (USEPA, 2001a). The outcome of this screening is that constituents are either excluded as COPCs or retained for further evaluation in the BERA process.

The refinement of surface water and sediment COPCs is based on four steps: (1) data grouping, (2) identification of SLERA COPCs for each data grouping, (3) refined screening against background and ESVs, and (4) identification of Step 3a COPCs to be carried forward into the refined risk calculations.

(1) Data Groupings

Surface water and sediment data sets remain in on Site and off Site data groupings, as presented in the SLERA. These data sets are further subdivided into Eastern Drainage and Western Drainage data sets, as identified in Appendix C, Table C. Background data for each medium and data set are also identified. Note that surface water samples were not available for an evaluation of the on Site Eastern Drainage data set because the on Site Eastern Drainage channels were dry during the sampling event. Appendix C, Tables C-6, C-7, and C-8 provide the following information (based on the data groupings identified in Table C-1):

- Table C-6a: Occurrence of Constituents in Surface Water (Eastern Drainage: Off Site)
- Table C-6b: Occurrence of Constituents in Surface Water (Western Drainage: On Site)
- Table C-6c: Occurrence of Constituents in Surface Water (Western Drainage: Off Site)

- **Table C-7a: Occurrence of Constituents in Sediment (Eastern Drainage: On Site)**
- **Table C-7b: Occurrence of Constituents in Sediment (Eastern Drainage: Off Site)**
- **Table C-7c: Occurrence of Constituents in Sediment (Western Drainage: On Site)**
- **Table C-7d: Occurrence of Constituents in Sediment (Western Drainage: Off Site)**
- **Table C-8a: Occurrence of Constituents in Background Surface Water (Eastern and Western Drainages)**
- **Table C-8b: Occurrence of Constituents in Background Sediment (Eastern and Western Drainages)**

(2) Identification of SLERA COPCs for each Data Grouping

Constituents identified as COPCs in the SLERA (Sections VII. C.2.a. and VII. C.4.) are carried into the refinement process in the subdivided data sets (Eastern-On Site; Eastern-Off Site; Western-On Site; Western-Off Site). For example, any constituent identified as an “off Site surface water COPC” in the SLERA is identified for both the “Eastern Drainage: Off Site” and the “Western Drainage: Off Site” refinement of COPCs evaluations.

(3) Refined Screening

For each data grouping, refined screening involves consideration of maximum detected concentrations, exposure point concentrations (EPCs), background concentrations, and SLERA ESVs. Note that the EPCs are 95 percent upper confidence limit (UCL) estimates of mean concentrations, unless UCLs exceeded the maximum concentration, in which case the maximum concentration is used as the EPC. Within each data grouping, the EPCs are compared to appropriate background data. It should be noted that calcium, magnesium, potassium, and sodium are not evaluated in this manner because they are essential nutrients (USEPA, 2001a) and were typically detected at or less than twice background concentrations. For those constituents that have EPCs greater than the background constituents, the EPCs are then compared to SLERA ESVs (i.e., the same ESVs used for risk calculations in the SLERA [Section VII. C.2.a.]). Constituents are carried forward as Step 3a COPCs when both of the following conditions are met:

- EPCs exceed background (or no background value is available), and
- EPCs exceed SLERA ESVs (or no ESV is available).

(4) Identification of Step 3a COPCs

The identification of the Step 3a COPCs is provided for each data grouping using the refinement process described above, on Tables VII-9 (a through c) and VII-10 (a through d) as follows:

- Table VII-9a: Refinement of Direct Contact Surface Water COPCs (Eastern Drainage: Off Site)
- Table VII-9b: Refinement of Direct Contact Surface Water COPCs (Western Drainage: On Site)
- Table VII-9c: Refinement of Direct Contact Surface Water COPCs (Western Drainage: Off Site)
- Table VII-10a: Refinement of Direct Contact Sediment COPCs (Eastern Drainage: On Site)
- Table VII-10b: Refinement of Direct Contact Sediment COPCs (Western Drainage: Off Site)
- Table VII-10c: Refinement of Direct Contact Sediment COPCs (Eastern Drainage: On Site)
- Table VII-10d: Refinement of Direct Contact Sediment COPCs (Western Drainage: Off Site)

The COPCs carried forward into Step 3a based on the refinement described in this section are:

Summary of Direct Contact COPCs for Each Medium	
Data Grouping	COPCs
Surface Water	
Eastern: Off Site (Table VII-9a)	Cadmium, manganese, sulfate, zinc
Western: On Site (Table VII-9b)	Cadmium, nickel, sulfate, zinc
Western: Off Site (Table VII-9c)	Aluminum, cadmium, manganese, sulfate, zinc
Sediment	
Eastern: On Site (Table VII-10a)	Aluminum, barium, cadmium, zinc
Eastern: Off Site (Table VII-10b)	Aluminum, barium, beryllium, cadmium, copper, lead, manganese, mercury, nickel, vanadium, zinc

Western: On Site (Table VII-10c)	Cadmium, copper, lead, mercury, nickel, selenium, vanadium, zinc, 2-butanone, acetone, cis-1,2-dichloroethene
Western: Off Site (Table VII-10d)	Aluminum, arsenic, barium, cadmium, copper, lead, mercury, nickel, selenium, zinc

b. Refinement of Direct Contact Risk Calculations for Aquatic Wildlife

This section describes the process used to refine risk calculations (Section VII. D.1.a.i.), identifies the HQs greater than 1, presents an interpretation of the significance of those HQs (Section VII. D.1.b.ii.), identifies the constituents lacking ESVs in this refinement process, provides an interpretation of whether these constituents may be problematic (Section VII. D.1.b.iii.), and provides an overall summary of estimated risks to aquatic wildlife (Section VII. D.1.b.iii.).

i. Refinement Process

In Step 3a of the BERA, the SLERA risk calculations are refined for direct contact COPCs by recalculating HQs using more realistic exposure estimates and/or more realistic toxicity values. In this refinement, location-specific concentrations are used rather than exclusively the maximum detected concentrations from the data groupings that were used in the SLERA. The refinement of the risk calculations also involves the use of expanded ESVs, as described below.

Surface Water

The chronic ESVs that were presented in the SLERA are used for the calculation of location-specific HQs (thus, the maximum HQ seen in the SLERA will be seen again, with its specific location identified). In addition, this expanded screening uses the acute Illinois Water Quality Standards (or National Recommended Water Quality Criteria if Illinois values are not available) for the calculation of location-specific HQs (the available surface water ESVs are summarized on Table VII-1a). Both chronic and acute values are appropriate for this refinement, as the chronic values illustrate the potential risks associated with long-term exposures for aquatic wildlife while the acute values illustrate the potential risks with short-term exposures for aquatic wildlife. For a limited number of constituents, acute and chronic ESVs are not available. For these constituents, Secondary Chronic ESVs from the SLERA remain the only ESVs available for use.

Sediment

Sediment ESVs that were presented in the SLERA are also used for the calculation of location-specific HQs (the available sediment ESVs are summarized on Table VII-2). In addition, ESVs such as the NOAA probable effects levels (PELs) and the USGS severe effects levels (SELs) are used. The use of these values allows for a greater understanding of whether impacts are “probable” or might be “severe.”

The refined risk calculations for aquatic wildlife exposed to surface water and sediment are summarized, on Tables VII-11a through VII-12d, as follows:

- Table VII-11a: Refined Surface Water Direct Contact Risk Calculations (Eastern Drainage: Off Site)
- Table VII-11b: Refined Surface Water Direct Contact Risk Calculations (Western Drainage: On Site)
- Table VII-11c: Refined Surface Water Direct Contact Risk Calculations (Western Drainage: Off Site)
- Table VII-12a: Refined Sediment Direct Contact Risk Calculations (Eastern Drainage: On Site)
- Table VII-12b: Refined Sediment Direct Contact Risk Calculations (Eastern Drainage: Off Site)
- Table VII-12c: Refined Sediment Direct Contact Risk Calculations (Western Drainage: On Site)
- Table VII-12d: Refined Sediment Direct Contact Risk Calculations (Western Drainage: Off Site)

ii. Identification and Interpretation of Direct Contact HQs Greater than 1

The COPCs with HQs greater than 1 are summarized on the following table for each medium and each data grouping (constituents with HQs less than or equal to 1, the threshold value, are not discussed further in the BERA). Following the summary table, the ranges of HQs, spatial distribution of the elevated HQs, and potential significance to aquatic wildlife are discussed in greater detail (sampling locations are depicted on Figure VII-5a).

Summary of Refined Risk Calculations: HQs Greater than 1

Constituent	Eastern Drainage			Western Drainage			
	On Site	Off Site		On Site		Off Site	
	SD HQs Table VII-12a	SW HQs Table VII-11a	SD HQs Table VII-12b	SW HQs Table VII-11b	SD HQs Table VII-12c	SW HQs Table VII-11c	SD HQs Table VII-12d
Arsenic							0.8-3
Aluminum						2-20	
Cadmium	0.2-2	0.2-3	0.2-10	2-90	60-600	0.2-10	0.2-100
Copper			0.09-3		0.3-3		0.03-20
Iron							1-2
Lead			0.08-3		0.9-8		0.2-90
Manganese		3	0.7-2				
Mercury					0.7-10		0.01-10
Nickel				0.1-2	0.3-2		0.3-2
Zinc	1-7	30-200	0.6-90	40-400	10-100	10-400	2-200
Acetone					3-5		

Blank cells indicate that the constituent was not detected, the ESV was not available, or the HQ was less than or equal to 1

Eastern Drainage HQs Greater than 1

Surface Water (off Site)

The evaluation of surface water in the Eastern Drainage (off Site) involved two sampling locations, ED-13 and ED-16 (Figure VII-5a), as briefly described below:

- Off Site (Table VII-11a) – ED-13 (located adjacent to the Site boundary, with very little aquatic habitat) and ED-16 (located near Lake Hillsboro, with higher quality aquatic habitat).
- At location ED-13, the only HQs greater than the threshold value of 1 are for cadmium (3, for chronic effects), manganese (3, for chronic effects), and zinc (30 to 200, for acute and chronic effects, respectively). At location SD-16, constituents were either not detected or not detected greater than background concentrations. It should be noted that sulfate was detected at concentrations greater than background at both locations;

however, since no ESVs were available for sulfate, HQs were not calculated.

The flow characteristics and habitat quality of the off Site Eastern Drainage are important for understanding the significance of the HQs that exceed the threshold value. Specifically, at location ED-13, the drainage consists of a small intermittent channel. Therefore, though the HQs for cadmium, manganese, and zinc are elevated at ED-13, the HQs are considered unlikely to be representative of significant ecological effects (particularly compared to flow and overall habitat quality). Furthermore, because the HQs for COPCS at ED-16 did not exceed background concentrations and/or the threshold value, any ecological effects in the Eastern Drainage would be expected to be of limited spatial scale.

Sediment (on Site and off Site)

The evaluation of sediment in the Eastern Drainage involved one on Site sampling location and four off Site locations (Figure VII-5b), as briefly described below:

- On Site (Table VII-12a) – ED-12 (located in the woods north of the manufacturing area, with very little aquatic habitat).
- Off Site (Table VII-12b) – ED-13 (located adjacent to the Site boundary, with very little aquatic habitat), and progressing toward Lake Hillsboro with sampling locations ED-14, ED-15, and ED-16 (ED-16 is located nearest Lake Hillsboro, with higher quality aquatic habitat than the other sampling locations).

On Site at location ED-12, the only PEL-based HQ greater than 1 is for zinc (3). At location ED-13 (just off Site), the only PEL-based HQs greater than 1 are for cadmium (4) and zinc (3) with an SEL-based HQ of 10). The HQs diminish strongly as the drainage flows towards Lake Hillsboro, with PEL-based HQs greater than 1 for zinc only at ED-14 (20), and ED-15 (2). However, at ED-16 (the farthest downstream location in the Eastern Drainage), the HQs are very similar to those at ED-13 (a PEL-based HQ of 3 for cadmium, and PEL- and SEL-based HQs of 30 and 10 for zinc).

This information indicates that effects to sediment-dwelling organisms may occur near the area where the Eastern Drainage flows off Site (i.e., near ED-13), and that effects may also occur near the confluence with Lake Hillsboro (i.e., near ED-16). It is important to note, however, that any effects in the vicinity of ED-13 are not expected to be significant given the flow characteristics and habitat quality in the Eastern Drainage (i.e., intermittent until it approaches Lake Hillsboro). However, based on the SEL-based HQ of 10 for zinc at ED-16 and that habitat supportive of sediment dwelling organisms is present in the vicinity of ED-16, significant ecological impacts to sediment-dwelling organisms in proximity to ED-16 cannot be ruled out (although of limited spatial scale).

Western Drainage HQs Greater than 1

This section provides a discussion of HQs greater than 1 in the Western Drainage, and provides a narrative discussion of the potential ecological significance of those HQs in consideration of the flow characteristics and habitat quality both on and off Site within the drainage.

Surface Water (on Site and off Site)

The evaluation of surface water in the Western Drainage involved three on Site locations (including two stormwater pond locations) and four off Site locations (Figure VII-5a), as briefly described below:

- On Site (Table VII-11b) – WD-9 (located upgradient from the pond in an area with very little aquatic habitat), WD-PN (located at the northern end of the pond), and ED-PS (located at the southern end of the pond)
- Off Site (Table VII-11c) – WD-7 (located at the outfall of the pond, with very little aquatic habitat), WD-6 (located along the unnamed drainage upstream from the confluence with the unnamed tributary, in a developed park/residential area), WD-12 (located in the unnamed tributary to Middle Fork Shoal Creek), and WD-8 (located in the unnamed tributary south of the Site)
- Off Site (Table VII-11c) – WD-7 (located at the outfall of the pond, with very little aquatic habitat), WD-6 (located along the unnamed drainage upstream from the confluence with the unnamed tributary, in a developed park/residential area), WD-12 (located in the unnamed tributary to

Middle Fork Shoal Creek), and WD-8 (located in the unnamed tributary south of the Site)

The HQs for the three on Site locations indicate that adverse impacts may occur due to cadmium and zinc in the surface water upstream of and in the pond. This is based on HQs ranging from 2 and 40 in the pond (for acute effects for cadmium and zinc, respectively), to 90 and 400 upstream of the pond (for chronic effects for cadmium and zinc, respectively). However, it is critical to note that background concentrations for cadmium and zinc are also associated with elevated HQs (e.g., a background HQ of 60 was calculated for zinc), and that the pond has been observed to support an abundance of fish, turtles, vegetation, and other aquatic life (see Section VII. B.1.a.). In addition, though the HQs for location WD-9 (upstream of the pond) and WD-7 (just downstream of the pond and off Site) are associated with the most elevated HQs, these locations represent the least quality habitat due to extremely low water flow.

Moving further downstream, and off Site, the cadmium and zinc HQs attenuate quickly. By the time the Western Drainage reaches WD-6 in the unnamed drainage and joins the unnamed tributary to Middle Fork Shoal Creek, the HQs are approximately equivalent to the background HQs.

Though this information indicates that effects to aquatic wildlife may occur on-Site, the “predicted” effects are contradicted by on-Site observations. In addition, the information indicates that effects to aquatic wildlife may occur at off Site locations near the property boundary. However, these locations are not associated with habitat that is supportive of aquatic organisms. Therefore, although some of the HQs for surface water in the Western Drainage indicate the potential for adverse impacts to aquatic organisms, the impacts are not considered to be ecologically significant.

Sediment (on Site and off Site)

The evaluation of sediment in the Western Drainage on Site involved one on Site sampling location (and its duplicate) and four off Site locations (Figure VII-5b) as briefly described below:

- On Site (Table VII-12c) – WD-9 and its duplicate WD-9d (located upgradient from the pond in an area with very little aquatic habitat)
- Off Site (Table VII-12d) – WD-7 (located at the outfall of the pond, with very little aquatic habitat), WD-6 (located along the unnamed drainage just before its confluence with the unnamed tributary), WD-4, WD-3, WD-2, and WD-1 (located in the unnamed tributary flowing north toward Middle Fork Shoal Creek in succession from near the Site to furthest downstream), and WD-8 (located in the unnamed drainage south of the Site)

On Site, at location WD-9, PEL-based HQs greater than 1 were calculated for cadmium (200), lead (3), mercury (3), and zinc (40). In addition, SEL-based HQs greater than 1 were calculated for cadmium (60), and zinc (10). The HQs at WD-7, the nearest downgradient location and the first off Site location, are roughly equivalent to the HQs at WD-9. However, by the time the Western Drainage reaches WD-6, the HQs are greatly diminished. Once the drainage reaches the unnamed tributary, the HQs are approximately equal to the background HQs.

This information indicates that effects to sediment-dwelling organisms in the Western Drainage may occur on-Site and off Site near the property boundary, and that those effects are possible until the confluence of the drainage with the unnamed tributary to Middle Fork Shoal Creek. It is important to note, however, that the effects are not expected to be ecologically significant due to be generally poor habitat in the areas with elevated HQs. The information for locations with higher quality habitat, such as the unnamed tributary to Middle Fork Shoal Creek, indicate conditions that are favorable for sediment-dwelling organisms.

iii. Constituents Lacking ESVs in Refined Direct Contact Risk Calculations

Aluminum, barium, beryllium, vanadium, 2-butanone, and cis-1,3-dichloroethene were detected in one or more sediment groupings but were not evaluated due to the lack of ESVs. Significant and or unacceptable risks are not expected for aquatic wildlife associated with these constituents because:

- Aluminum, barium, beryllium, selenium, and vanadium, are naturally occurring inorganic constituents that were detected in sediment at

concentrations generally consistent with background concentrations, (with only a very limited number of exceptions; Appendix B, Tables B-2 and B-5).

- Selenium was detected in sediment on Site and off Site in the Western Drainage, but only in two locations, WD-9 and WD-7 (Table B-2). Habitat is limited in both locations.
- 2-Butanone and cis-1,2-dichloroethene were detected in sediment at one location in an area of the Site with limited aquatic habitat (WD-9). VOCs were not detected in surface water or sediment in any off Site samples.

c. Overall Conclusions for Aquatic Wildlife

Based on the information developed and presented in the section, it can be concluded with reasonable confidence that ecologically significant adverse impacts to aquatic wildlife are not likely to be associated with Site-related constituents detected in the Eastern Drainage or Western Drainage. Although some of the calculated HQs predict adverse impacts to aquatic wildlife, the HQs were considered along with lines of evidence regarding the spatial distribution of chemicals, the available habitat quality, and observations of aquatic wildlife. Based on these multiple lines of evidence, it can be concluded that adverse impacts are not likely to occur in areas with the highest quality habitat. Further, elevated estimates of risk in the pond are not consistent with observations of the biological activity in the pond. Consideration of all available lines of evidence indicates that adverse impacts, due to site-related constituents, if occurring, are not likely to result in population, community, or ecosystem level impacts (however, future improvements to the physical condition and habitat of the site may result in unacceptable ecological risks that require further evaluation). Conclusions drawn at the population and community levels are appropriate in this ERA because it has been documented that threatened and endangered species are not present in the vicinity of the Site (USEPA 1999).

2. Refined Evaluation of Water/Dietary Exposures and Risks for Piscivorous Wildlife

This section presents the refinement of piscivorous water/dietary COPCs (Section VII. D.2.a.), the refinement of direct contact risk calculations for piscivorous wildlife (Section VII. D.2.b.), and overall conclusions regarding risks to piscivorous wildlife (4.2.3).

a. Refinement of Piscivorous Water/Dietary COPCs

The refinement of water/dietary prey COPCs is based on four steps, similar to the refinement of direct contact COPCs described in Section VII. D.1.a.: (1) data grouping,

(2) identification of SLERA COPCs for each data grouping, (3) refined screening against background and ESVs, and (4) identification of Step 3a COPCs to be carried forward into the refined risk calculations.

(1) Data Groupings – As described in Section VII. D.1.a., three surface water data groupings are available and used in the refinement of piscivorous water/dietary COPCs: Eastern Drainage-Off Site; Western Drainage-On Site; and Western Drainage-Off Site.

(2) Identification of SLERA COPCs for each Data Grouping – Constituents identified as COPCs in the SLERA (Sections VII. C.2.a. and VII. C.4.) are carried into the refinement process in the subdivided data sets. For example, any constituent identified as an “off Site piscivorous water/dietary COPC” in the SLERA is identified for both the “Eastern Drainage: Off Site” and the “Western Drainage: Off Site” refinement of COPCs evaluations.

(3) Refined Screening – For each data grouping, refined screening involves consideration of maximum detected concentrations, background concentrations, and SLERA ESVs. Within each data grouping, the EPCs are compared to appropriate background data. It should be noted that calcium, magnesium, potassium, and sodium are not evaluated in this manner because they are essential nutrients, have typically been detected at or less than twice background, and no ESVs are available. For those constituents that have EPCs greater than the background concentrations, the EPCs are then compared to the SLERA ESVs (i.e., the same ESVs used for piscivorous risk calculations in the SLERA (Section VII. C.2.a.)). Constituents were carried forward as Step 3a COPCs when both of the following conditions are met:

- EPCs exceed background (or no background was available), and
- EPCs exceed SLERA ESVs (or no ESV was available).

(4) Identification of Step 3a COPCs - The identification of the Step 3a COPCs is provided for each data grouping using the refinement process described above, on Tables VII-13a through VII-14c, as follows:

- **Table VII-13a: Refinement of Piscivorous Water/Dietary COPCs (Eastern Drainage: Off Site)**

- Table VII-13b: Refinement of Piscivorous Water/Dietary COPCs (Western Drainage: On Site)
- Table VII-13c: Refinement of Piscivorous Water/Dietary COPCs (Western Drainage: Off Site)

The COPCs carried forward into Step 3a based on the refinement described in this section are:

Summary of Piscivorous COPCs	
Data Grouping	COPCs
Off Site Eastern (Table VII-13a)	Cadmium, manganese, sulfate, zinc
On Site Western (Table VII-13b)	Cadmium, sulfate, zinc, cis-1,2-dichloroethene, trichloroethylene
Off Site Western (Table VII-13c)	Aluminum, cadmium, manganese, selenium, sulfate, zinc

b. Refinement of Piscivorous Risk Calculations

This section describes the process used to refine risk calculations (Section VII. D.2.b.i.), identifies the HQs greater than 1, presents an interpretation of the significance of those HQs (Section VII. D.2.b.ii.), identifies the constituents lacking ESVs in this refinement process, provides an interpretation of whether these constituents may be problematic (Section VII. D.2.b.iii.), and provides an overall summary of estimated risks to aquatic wildlife (Section VII. D.2.b.iiii.).

i. Refinement Process

In Step 3a of the BERA, the SLERA risk calculations are refined for piscivorous wildlife exposed to water/dietary prey by recalculating HQs using more realistic estimates of exposure and/or more realistic toxicity values. The recalculation of the HQs is summarized on Tables VII-14a, VII-14b, and VII-14c for the Eastern Drainage-Off Site, Western Drainage-On Site, and Western Drainage-Off Site, respectively.

The refined risk calculations are intended to reflect refined exposure estimates. Therefore, as seen on Tables VII-14a, VII-14b, and VII-14c, EPCs are used in the refined risk calculations. However, it should be noted that the EPCs are the maximum detected concentrations rather than the UCL concentrations (i.e., the UCLs exceeded the maximum concentrations due to the small size of the data sets).

An alternative method to evaluate a range of exposure estimates is discussed further in this section on a chemical-specific, location-specific basis.

The refined risk calculations also are based on refined effects estimates. Therefore, refined piscivore risk calculations use ESVs based on both NOAELs, and lowest observable adverse effects levels (LOAELs). The toxicological basis and references for LOAELs are summarized in Appendix D, Table D-1a.

ii. Identification and Interpretation of Piscivorous HQs Greater than 1

The COPCs with HQs greater than 1 are summarized on the following table for each data grouping and receptor (constituents with HQs less than or equal to 1 are not discussed further in the BERA). Following the summary, the ranges of HQs, spatial distribution of the elevated HQs, and potential significance to aquatic wildlife are discussed in greater detail (sampling locations are depicted on Figure VII-5a).

Summary of Refined Risk Calculations: HQs Greater than 1

Constituent	Eastern Drainage		Western Drainage			
	Off Site (Table VII-14a)		On Site (Table VII-14b)		Off Site (Table VII-14c)	
	Mink HQs	Heron HQs	Mink HQs	Heron HQs	Mink HQs	Heron HQs
Aluminum					6-60	
Cadmium	2-20	0.8-7	50-500	30-200	8-80	4-30
Selenium					3-5	0.9-2
Zinc	6-10	10-100	10-30	30-300	10-30	30-300

Blank cells indicate either the constituent was not detected or the HQ was less than or equal to 1

HQs are based on maximum detected concentrations, while range shows NOAEL HQ to LOAEL HQ.

As previously stated, the HQs that were calculated for both receptors (i.e. heron and mink) in the refined risk calculations are based on maximum detected concentrations due to small data sets. Therefore, it is extremely unlikely that either receptor would be exposed to maximum detected concentrations on a long-term basis. In reality, heron will only spend a small portion of their time in either the Eastern or Western Drainages, and it is highly unlikely that sufficient aquatic habitat exists to support mink in the vicinity of the Site. Nevertheless, in order to refine and understand potential risks associated with the constituents identified

with HQs greater than 1, location-specific HQs are calculated, as follows (and discussed below):

- Table VII-15a: Location-Specific Piscivorous Water/Dietary HQs (Eastern Drainage: Off Site)
- Table VII-15b: Location-Specific Piscivorous Water/Dietary HQs (Western Drainage: On Site)
- Table VII-15c: Location-Specific Piscivorous Water/Dietary HQs (Western Drainage: Off Site)

Eastern Drainage: Off Site

The evaluation of off Site surface water in the Eastern Drainage involved two sampling locations, SW-ED-13 and SW-ED-16. Location ED-13 is adjacent to the Site boundary, while ED-16 is near Lake Hillsboro (Figure VII-5a). At location ED-13, the only LOAEL-based HQs greater than the threshold value of 1 are for cadmium (2 for the mink) and zinc (6 for the mink and 10 for the heron). At location ED-16, no HQs were greater than 1. As noted previously, sulfate was detected at concentrations greater than the background concentration at both locations; however, since no NOAELs or LOAELs were available for sulfates, HQs were not calculated.

As described previously, the area of the Eastern Drainage in the vicinity of ED-13 does not have perennial flow, and does not provide mink habitat. Further, fish are rarely going to be present in much of this portion of the drainage, so even the heron will find little forage opportunity. Fish communities, however, may be present in the vicinity of Lake Hillsboro. Note that cadmium and zinc were either not detected at ED-16, or detected at concentrations less than background. Therefore, adverse impacts are not expected for mink or heron in the Eastern Drainage.

Western Drainage: On Site

The evaluation of on-site surface water in the Western Drainage involved three sampling locations (Table VII-15b; Figure VII-5a). The HQs are greater than the threshold value for cadmium and zinc at all three locations. For the mink, zinc HQs range from approximately 8 to 30, and cadmium HQs range from 20 to 500. HQs of these magnitudes indicate that adverse impacts could occur for mink that obtain 100 percent of their diet from fish in the

pond. However, mink home ranges are large in relation to the pond and mink diets are very diverse, including fish, a broad array of other aquatic organisms (crayfish, amphibians), aquatic oriented mammals and waterfowl (muskrat, ducks), and terrestrial mammals and birds (rodents, rabbit, and ground dwelling birds) (USFWS, 1984). Mink home ranges are comprised of relatively large areas; studies have shown that mink home ranges can range from 0.5 miles to 3 miles, depending on the quality of the habitat and the availability of food (Stokes and Stokes, 1986). Within their home ranges throughout the year, male and female mink find suitable habitat near streams characterized by abundant cover (e.g., emergent wetlands and fallen trees snags) and pools for foraging (USFWS, 1984; Stokes and Stokes 1986). Mink avoid exposed or open areas, with greater than 50 percent canopy cover being considered suitable (USFWS, 1984). More than half of the on Site pond shoreline lacks the cover needed by mink. Furthermore, the shallow drainage that flows downstream from the pond does not provide the flow regime nor forage habitat preferred by mink until the confluence with the unnamed tributary (and in the unnamed tributary the cover is suboptimal). Therefore, since the pond is approximately 1 acre in area, both the amount of exposure that mink would have to the pond (and downstream drainage areas) and the number of mink exposed to the pond would be severely limited. As a result, even if adverse impacts to mink related to cadmium and zinc in the pond were to occur, these impacts would be very limited and would not be expected to result in impacts to a mink population. Even with greater use of the pond by mink should habitat conditions change, fish from the pond will remain a small portion of the mink diet, resulting in only limited impacts (if any) to a limited number of individual mink.

Adverse impacts to the green heron cannot be ruled out based only on the HQs and consideration of habitat. Green heron have been seen foraging in the pond, and could spend appreciable amounts of time at the pond given the known presence of fish. In addition, the LOAEL HQs for the heron in the pond are 10 for zinc and 10 for cadmium, indicating that adverse impacts to these receptors would be expected for heron that live 100 percent of the time at the pond. These HQs are based on LOAELs that reflect the reproductive ability of birds exposed to levels of zinc and cadmium. HQs greater than 1 for both zinc and cadmium for the LOAELs indicates that reproductive effects are likely to be observed for heron that feed exclusively in the pond.

Specifically, birds exposed exclusively to the pond may lay fewer eggs due to cadmium exposure and eggs may have less hatching success due to zinc exposure (Sample et al. 1996). However, when consideration is given to the percent of time heron are likely to spend at the pond (given heron home ranges and migration patterns) as well as the limited number of heron likely to be exposed, adverse impacts to the heron are not likely to be ecologically significant.

Refinement of the risk calculations involves consideration of reasonable exposure assumptions. Therefore, the percent of time heron are likely to spend at the pond as well as the limited number of heron likely to be exposed needs to be considered. The pond is small, and is unlikely to represent even one heron's entire foraging range. Home ranges for waterfowl vary greatly, and are very dependent on the available aquatic resources of any given area (National Geographic, 1999). Green heron that visit the pond are very likely to forage in on Site and off Site drainages. Further, heron are likely to utilize the higher-quality habitat of Lake Hillsboro and the Bremer Sanctuary. Further, heron, and other piscivorous bird species are migratory, so they are only likely to spend approximately 50 percent of their time in Illinois in any given year (National Audubon Society, 2004). As a result, actual exposure is expected to be much less than that predicted using the HQ calculations. Finally, only a limited number of individual heron are likely to be present at the pond in any given year.

Therefore, considering all of these variables, it is very reasonable to expect that adverse impacts may not occur for green heron that feed in the pond as part of their forage range. Further, even if adverse impacts do occur for an individual green heron that feeds in the pond a disproportionate amount of the time, the adverse impacts are likely to be very isolated, and are not likely to affect heron populations.

Western Drainage: Off Site

The evaluation of surface water in the Western Drainage (off Site) involved four locations, though some were sampled on multiple occasions (Table VII-15b; Figure VII-5a). Cadmium and zinc HQs off Site are most elevated in the area with the least available habitat. The most elevated HQs

were seen at location WD-7, a location repeatedly identified as the pond outfall with only a few inches of water and no fish habitat.

The unnamed tributary flowing north toward Middle Fork Shoal Creek does have aquatic habitat that supports fish and piscivorous wildlife (potentially even the mink). Adverse impacts are not expected for piscivorous wildlife because, as seen at location WD-12, cadmium and zinc were detected below background concentrations in this unnamed tributary to Middle Fork Shoal Creek. Similarly, cadmium and zinc were detected below background at location WD-8 in the unnamed tributary south of the Site. Location WD-6 is located near the confluence of the unnamed drainage and the unnamed tributary. Habitat in this residential area is not sufficient to support fish on a perennial basis (as discussed in Section VII. B.1.a. and seen in Photograph 23). Three samples were collected from this location [denoted WD-6a, WD-6b, and WD-6bd, for samples collected March 2003, and June 2003 (i.e., a duplicate sample was collected in June 2003)]. HQs greater than 1 were seen for aluminum, selenium, cadmium and zinc. Aluminum and selenium were isolated occurrences, as they were not seen at other locations, so the remainder of this discussion is focused on zinc and cadmium. The zinc results from location WD-6 in June 2003 (4 mg/L for WD-6b, and 3.6 mg/L for WD-6bd) show detected concentrations very similar to background (3.7 mg/L). Table VII-15c shows HQs for location WD-6b and WD-6bd range from 2-4 for the mink and 5-50 for the heron. These HQs for concentrations so comparable to background illustrate the conservative nature of the HQ estimates. Elevated zinc concentrations seen in the WD-6a sample did yield greater HQs ranging from 8-20 for the mink and 20-200 for the heron. But, concentrations seen just three months later show the transient nature of the exposures wildlife may experience. Similarly, elevated cadmium HQs seen from the sample collected in March was reduced in June (though still greater than 1). Exposures to both mink and heron at location WD-6 would be very limited, as water flow at WD-6 is intermittent and does not support fish on an annual basis. In addition, exposures are further limited based on the home range and migratory patterns already discussed for the heron (i.e., the heron will use a variety of habitat for forage, and they migrate a portion of the year). Similar home range issues apply for the mink as well, so the elevated HQs do not reflect the true exposures that are likely to occur. Given this analysis of habitat and HQs, it is very reasonable to expect that adverse

impacts are not likely to occur for heron and mink in the Western Drainage off Site.

iii. Constituents Lacking ESVs in Piscivorous Risk Calculations

Manganese was detected in two of the data groupings, but could not be evaluated due to the lack of ESVs. Risks associated with manganese is not expected because it is a naturally occurring constituent that was also detected in background locations at concentrations similar to the non-background locations.

c. Overall Conclusions for Piscivorous Wildlife

Based on the information developed and presented in this section it can be concluded with reasonable confidence that ecologically significant adverse impacts to piscivorous wildlife are not likely to be associated with Site related constituents detected in the Eastern Drainage or the off Site Western Drainage. Although some of the calculated HQs predict adverse impacts to piscivorous wildlife, the HQs were considered along with lines of evidence regarding the spatial distribution of chemicals, the available habitat quality, and observations of aquatic wildlife. Based on these multiple lines of evidence, it can be concluded that adverse impacts to piscivorous wildlife are not likely to occur in the Eastern Drainage or off Site in the Western Drainage.

In the Western Drainage, the on-site stormwater pond presents challenges for understanding potential risks to piscivorous wildlife. Adverse impacts to mink can be ruled out base on exposure considerations. Specifically, exposures would occur for only a limited number of mink, and only for short durations as the pond only provides a small portion of the home range. Further, fish from the pond would comprise a small portion of the food in a mink's diet. Therefore, if adverse impacts related to cadmium and zinc in the pond were to occur, these impacts would be very limited and are not considered likely to result in impacts to a mink population.

With regard to the green heron, adverse impacts due to potential exposure to the water in the pond cannot be ruled out based on HQs and consideration of habitat alone. However, if more realistic exposure is considered, it is likely that adverse impacts will not occur for heron that feed in the pond because the pond is likely to be a small part of its home range (which would include higher quality habitat in the unnamed tributary, Middle Fork Shoal Creek, Lake Hillsboro, and the Bremer Sanctuary). Further, if adverse impacts do occur for an individual green heron that feeds in the pond a disproportionate amount of the time, the adverse impacts are likely to be very isolated, and would not affect heron populations. Finally, elevated estimates of risk in the pond are not consistent with observations of the biological activity in the pond. Consideration

of all available lines of evidence indicates that adverse impacts, if occurring, are not likely to result in population, community, or ecosystem level impacts. As mentioned previously in Section VII. D.1.c., conclusions drawn at the population and community levels are appropriate in this ERA because it has been documented that threatened and endangered species are not present in the vicinity of the Site (USEPA 1999).

3. Refined Evaluation of Food Web Exposures and Risks for Terrestrial Wildlife

This section presents the refinement of terrestrial wildlife COPCs (Section VII. D.3.a.), the refinement of food web risk calculations for terrestrial wildlife (Section VII. D.3.b.), and overall conclusions regarding risks to terrestrial wildlife (Section VII.D.3.c.). Note that data grouping involved a single data set, and subgrouping similar to that seen for aquatic drainages was not required.

a. Refinement of Terrestrial Food Web COPCs

The refinement of COPCs for terrestrial wildlife is identified on Table VII-16 for each of the three receptor species (i.e., deer mouse, American robin, and red-tailed hawk). Specifically, COPCs are identified for the refinement of risk calculations if both of the following conditions are met (1) the constituent was previously identified in the SLERA for a given receptor, and, (2) surface water or soil EPCs exceed background concentrations. As a result, the COPCs included retained for each receptor based on the considerations just described are:

Summary of Terrestrial Wildlife COPCs	
Receptor	COPCs
Deer Mouse	Cadmium, lead, selenium, zinc
Robin	Cadmium, chromium, lead, mercury, zinc
Hawk	Cadmium, zinc

b. Refinement of Terrestrial Wildlife Risk Calculations

This section describes the process used to refine risk calculations (Section VII. D.3.b.i.), identifies the HQs greater than 1 with an interpretation of the significance of those HQs (Section VII. D.3.b.ii.), and provides an overall summary of estimated risks to terrestrial wildlife (Section VII. D.3.b.iii.).

i. Refinement Process

Risk calculations are refined for terrestrial wildlife by recalculating HQs using identical mathematical formulae previously described in the SLERA (Section VII. C.1.c.i.; Appendix D, Tables D-2a, D-2b, and D-2c) for the mouse, robin, and hawk, respectively). Although intake formulae did not change between the SLERA and this BERA, more realistic estimates of exposure and effects than those used in the SLERA were used in this BERA refinement process.

The recalculation of the HQs is summarized on Tables VII-17a, VII-17b, VII-17c for the deer mouse, American robin, and red-tailed hawk, respectively. The exposure and effects assumptions that were included in this refined risk calculation process are described below.

Exposure Assumptions

Media concentrations, species-specific wildlife exposure parameters, and bioaccumulation/bioconcentration factors used in this refinement reflect more realistic exposure assumptions than those used in the SLERA, as described follows:

1. The ***media concentrations*** used for the refinement are exposure point concentrations that reflect the upper estimate of the average concentration (i.e., the UCL). These values replace the maximum detected concentrations that were used in the SLERA. The medium-specific exposure estimates used in the refinement are identified on Tables VII-17a, VII-17b, and VII-17c, for the mouse, robin, and hawk.
2. ***Wildlife exposure parameters*** include average estimates of body weight, ingestion rate, dietary parameters, exposure duration, and Site foraging frequency. The exposure parameters used in the SLERA were intentionally conservative to estimate the worst-case exposures, and in the BERA these assumptions are modified to reflect more realistic exposures (USEPA 1997; 2000a; 2001a). For example, average body weights and ingestion rates are used. In addition, home range is used to provide a more realistic estimate of the time a given species may spend at the Site. Similarly, the red-tailed hawk and American robin are known to migrate during winter. Using this information, more realistic exposure durations are estimated. The exposure parameters used, with the rationales for selections and sources cited, are identified in Appendix D (Tables D-3a, D-3b, and D-3c) for the mouse, robin, and hawk, respectively).

3. *The Bioaccumulation and bioconcentration factors* used for the refined risk calculations are provided on Tables VII-17a, VII-17b, and VII-17c, for the mouse, robin, and hawk. The values used are the average values identified by Sample et al. (1998a&b) and Bechtel (1998) rather than the 90 percentile values used in the SLERA (the full compilation of bioaccumulation and bioconcentration factors used in the SLERA and BERA is provided in Appendix D, Table D-4).

Effects Estimates

The refined risk calculations included refining the ecological effects estimates (i.e., the toxicity values). The SLERA considered only NOAELs, which provide insight into concentrations that will cause "no observable adverse effects." This refined analysis includes the same NOAEL values, but also includes LOAEL values, which provides insight into the lowest concentrations that have been identified as being associated with an observable effect.

ii. Identification and Interpretation of Terrestrial HQs Greater than 1

The COPCs with HQs greater than 1 are summarized on the following table for each receptor (constituents with HQs less than or equal to 1 are not discussed further in the BERA). Following the summary table, the ranges of HQs, spatial distribution of the elevated HQs, and potential significance to terrestrial wildlife are discussed in greater detail (sampling locations are depicted on Figure VII-5c).

Summary of Refined Risk Calculations: HQs Greater than 1

Constituent	Deer Mouse		American Robin		Red-Tailed Hawk	
	LOAEL HQs	NOAEL HQs	LOAEL HQs	NOAEL HQs	LOAEL HQs	NOAEL HQs
Cadmium	2	20		20		
Zinc	2	3	6	50		3

Blank cells indicate either the constituent was not detected or the HQ was less than or equal to 1
 HQs are based on maximum detected concentrations, while range shows LOAEL HQ to NOAEL HQ.

Deer Mouse and American Robin

Adverse impacts are not expected to be ecologically significant for deer mouse and American robin, but there are three specific samples that are giving the impression of more broad based potential effects. Deer mouse HQs range from 2-20 for cadmium and 2-3 for zinc, while robin HQs range from 1-20 for cadmium and 6-50 for zinc. As indicated in Tables D-1b and D-1c, the LOAELs are based on reproductive effects for mammals and birds. LOAEL HQs in the range of 2-6 for deer mice and robins indicates that mammals and birds may be exposed, on average, to concentrations of cadmium and zinc that could cause adverse impacts. These HQs are meaningful because they are based on average exposures, using relatively realistic estimates of exposure and effects. The HQs for cadmium and zinc for both species are most sensitive to (i.e., influenced the most by) soil concentration (ingestion of invertebrates/earthworms actually leads to the elevated HQs, but earthworm tissue concentrations are closely correlated to soil concentrations). A close evaluation of soil concentrations used for this assessment (see Table B-3) shows that there were two samples collected under the residue material that significantly influenced the EPC. These were samples A1-06 and A1-23. These two locations had the two greatest detected zinc concentrations (11,000 mg/kg and 5,700 mg/kg), and two of the three highest cadmium concentrations (87 mg/kg and 56 mg/kg). A third cadmium concentration of 70 mg/kg was seen at location WA-09. These detected cadmium and zinc concentrations are not characteristic of the remainder of the soil data set and lead to an overestimate of risk. It is likely that these skewed analytical results are an artifact of efforts to sample beneath residue and are not indicative of soil concentrations at the Site (i.e., fragments of residue could have been included in the acid-digestion and analysis).

Deer mice and robins are not likely experiencing any current adverse impacts because the soil data set used for this evaluation, including the three elevated results discussed above, are not currently accessible (i.e., they are underneath residue material). Furthermore, the elevated concentrations are not present in areas with suitable wildlife habitat. On the other hand, locations in the Northern Area (NA-08, NA-09, and NA-09D) have zinc and cadmium at concentrations orders of magnitude less than the cadmium and zinc EPCs. Further, the Northern Area is the location with existing habitat; thus, deer mice and robin on Site are currently not likely to be experiencing any

significant exposure or impacts. Therefore, based on consideration of data and its spatial distribution at the Site, adverse impacts are not expected to be ecologically significant for deer mouse and American robin.

Red-Tailed Hawk

The HQs calculated for the red-tailed hawk are very low (the greatest HQ is a NOAEL-based value of 3 for zinc). Therefore, adverse impacts are not expected for red-tailed hawks that may forage at the Site. Further, adverse impacts are not expected for any other raptor that forages at the Site, as the red-tailed hawk is assumed to represent a wide range of species within this trophic level.

c. Overall Conclusions for Terrestrial Wildlife

Significant adverse impacts are not likely for the deer mouse, American robin, or red-tailed hawk.

4. Refined Evaluation of Uncertainties

The characterization of uncertainty is a component of the ERA process (USEPA, 1997). This section provides a narrative discussion of the types of uncertainties that exist in an ERA, with a focus (when possible) on how these uncertainties affect the conclusions drawn for the Eagle Zinc Site. Some of these uncertainties were identified previously in the SLERA (Table VII-5a), as the general principles apply in both approaches. The difference between the SLERA and BERA, however, is the reduction in uncertainties in the BERA (when possible) through the use of Site-specific information. In addition, while a SLERA is based on the most conservative assumptions in areas where uncertainty exists, a BERA uses more realistic assumptions (USEPA 1997; 2000a; 2001a).

Toxicological Uncertainties

The ERA for the Eagle Zinc Site is based on ecotoxicological benchmarks (e.g., ESVs) such as NOAELs, LOAELs, acute and chronic criteria, probable effects levels, and severe effects levels from a broad range of sources. The use of the range of benchmarks is intended to reduce the uncertainty associated with the conservative SLERA assumptions. However, uncertainties associated with bioavailability and toxicity exist, for example:

- The benchmarks used in the BERA for the Eagle Zinc Site, although less conservative than those used in the SLERA, still do not take into account diminished

bioavailability due to mitigating factors such as acid volatile sulfides (AVS) or total organic carbon (TOC). Risks can be significantly overestimated because data related to the AVS and TOC components of sediments at the Eagle Zinc Site are not available for consideration. For example, it is well known that AVS and TOC diminish the bioavailability, and thus toxicity, of metals such as zinc and cadmium (Chapman 1996; Sprague 1985; DiToro 2001, Santoro 2001; Alexander 2000). Most trace metals do not form distinct sulfides but are sorbed onto pyrite and iron monosulfides that have been proved to control the mobility, potential toxicity and ultimate fate of elements such as zinc and cadmium (Morse 1994).

- The USEPA's National Recommended Water Quality Criteria (and ultimately state criteria, such as Illinois) are expressed in terms of the dissolved metal in the water column (NOAA, 1999; USEPA, 2002). According to USEPA, "concentrations of dissolved metals rather than total metals should be used to set and measure compliance with water quality standards" because dissolved metals are considered the biologically available fraction (USEPA, 1996). Metals that are not biologically available, but may be detected in total metals analyses, do not cause toxicity to aquatic organisms and do not readily bioaccumulate in aquatic organisms (Newman, 1998). Dissolved metals data are not available for the Eagle Zinc Site; thus, the degree to which aquatic organisms (and fish and piscivorous wildlife) are actually exposed is unknown. However, because dissolved metals are always a fraction of total metals, one can generally assume that exposures estimated using total metals data exceeds actual exposures, thereby overestimating risks.
- Tolerance and adaptation are not considered directly in the BERA, though it is well known that biological organisms have the capacity to tolerate elevated conditions and adapt to an environment when exposed on a long-term basis (Millward and Klerks 2002; Grant 2002). The presence of fish and other aquatic wildlife in the Western Drainage stormwater pond where HQs predicted adverse impacts may be an example of tolerance and adaptation, an indication of diminished bioavailability, or both.
- Uncertainties in toxicological data do not always lead to the overestimation of risks, as there are some uncertainties for which the effect on the risk assessment process is unknown. For example, the field of ecotoxicology has not developed to a point that allows characterization of ecological risks with a high degree of certainty (Kapustka and Landis, 1998; Newman, 1998; Lovett Doust, et al., 1993). Uncertainty is inherent in conclusions drawn based on the use of these values, in part, because the science of ecotoxicology is relatively young and not yet fully developed. Toxicity data are only available for a limited number of species (most of them laboratory test

species) under a defined set of test conditions (which very likely deviate from natural conditions). In current practice, more than 95 percent of the resources in toxicology are focused toward the study of single chemicals (Cassee, et al. 1998), and the majority of these are focused toward single species (Sample et al. 1996; Newman 1998). Most of the single chemical single species testing is performed under highly controlled laboratory conditions, which are very likely deviate from conditions at any Site. Furthermore, simplistic extrapolations from laboratory species to wildlife species and testing conditions to field conditions may not be accurate, and are rarely, if ever, validated against natural conditions (Power 1996).

- Some uncertainties in toxicological data also lead to the underestimate of risk. For example, a chemical-specific ERA cannot evaluate risks from all chemicals due to the lack of benchmarks for some of those chemicals. However, the situation was not a major factor at the Eagle Zinc Site due to the nature of the chemicals for which benchmarks were not available (i.e., primarily nutrients).

Risk Characterization Uncertainties

There are uncertainties associated with interpreting individual versus population level impacts using HQs. HQs provide some insight into the types of impacts an individual organism may experience when exposed to chemicals, but they do not provide insight into population impacts (Sorensen et al. 2004). A population is considered the smallest ecological unit that persists through time (Durda and Prezoisi, 1999), and the USEPA requires protection of population, communities, and ecosystems (USEPA, 1999). Protection of individuals is only specifically required for threatened and endangered species (USFWS 1973; USEPA 1999). Estimates of impacts on populations and communities at the Eagle Zinc Site were inferred based on consideration of HQs within the context of habitat quality and wildlife habitat use characteristics. Because it has been documented that threatened and endangered species are not present on Site, protection of populations and communities are appropriate for the Site. Therefore, the elevated HQs were interpreted within the context of habitat quality and wildlife use of the resources on Site. By understanding these interactions, one can begin to interpret HQs with regard to potential-population level impacts (if any).

5. Scientific Management Decision Point

As previously mentioned, SMDPs represent critical steps along the process where multi stakeholder risk management decision-making occurs. It is at the SMDPs where the salient aspects of the ecological risk assessment are integrated in a manner that allows for informed risk management. Therefore, it is useful at this point to reiterate the critical context and

findings of this ecological risk screening evaluation and, on those bases, provide a conclusion for the Eagle Zinc Site. Specifically:

- Threatened and endangered species are not present at or in the vicinity of the Site.
- Adverse impacts associated with exposure to site-related constituents in surface water and sediment are predicted, typically in areas with poor habitat characteristics, and/or of limited spatial extent.
- Adverse impacts associated with exposure to site-related constituents in soil are not likely.
- Observations by biologists and ecologists during multiple Site reconnaissance activities did not result in the identification of adverse ecological impacts to individuals, populations, or communities.

Based on this information, the few exposure scenarios where adverse impacts due to potential exposures to site-related constituents are predicted are not indicative of ecologically significant impacts to populations, communities, or ecosystems (a primary risk management consideration according to USEPA [1999]). Indeed, it appears that less-than-adequate physical conditions (i.e., poor habitat quality) at and in the vicinity of the site currently restrict ecological function associated with the site far more than potential exposures to site-related constituents. Improvements to the physical condition and habitat of the site may result in unacceptable ecological risks that require further evaluation.

E. Acronyms

BERA	Baseline ecological risk assessment
°C	Celsius
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, Liability Information System
COPCs	Constituents of potential concern
CSM	Conceptual Site Model
EPC	Exposure point concentration
ERA	Ecological risk assessment
ESI	Environmental Site Investigation
ESV	Ecotoxicity Screening Value
HQ	Hazard quotient
IEPA	Illinois Environmental Protection Agency
ILDNR	Illinois Department of Natural Resources
IWPC	Illinois Water Pollution Control
LOAEL	Lowest Observed Adverse Effects Level
NOAA	National Oceanographic and Atmospheric Administration
NOAEL	No Observed Adverse Effects Level
NPDES	National Pollution Discharge Elimination System
NRWQC	National Recommended Water Quality Criteria
NWI	National Wetlands Inventory
PEL	Permissible Exposure Limit
PSER	Preliminary Site Evaluation Report
OME	Ontario Ministry of the Environment
RIFS	Remedial Investigation/Feasibility Study
RSI	Risk Sciences International
SLERA	Screening-level ecological risk assessment
SEL	Severe Effects Level
SMDP	Scientific management decision point
T&E	Threatened and Endangered
TEL	Threshold Effects Level
UCL	Upper Confidence Limit
USEPA	United States Environmental Protection Agency
USFWS	United States Fish & Wildlife Service
VOCs	Volatile organic compounds
XRF	X-ray Fluorescence

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VIII. CONCLUSIONS

A. Investigation Phases

Comparison of the RI data to conservative Screening Levels resulted in the identification of PCOCs and PAOCs for soil, sediment and residues (Phase 1) and ground water and surface water (Phase 2). The PCOCs, PAOCs and preliminary exposure pathways determined following completion of the investigative phases are summarized in Section V and formed a basis for further data evaluation in the HHRA and ERSE. Specifically, the soil PAOCs identified in the Phase 1 investigation were isolated on-Site areas where cadmium, arsenic, zinc, or a combination of these metals exceeded the Screening Levels.³¹ The sediment PAOCs identified in the Phase 1 investigation were limited portions of the eastern and western drainageways where concentrations of metals (zinc, lead, cadmium, antimony, arsenic, or combinations of these metals) and the VOC vinyl chloride exceeded the Screening Levels. The ground water PAOC identified in the Phase 2 investigation included a limited portion of the southwest area of the site and a small adjacent off-Site area that exceeded the Screening Levels for certain metals or sulfate. The surface water PAOCs identified in the Phase 2 investigation included certain portions of both drainageways that exceeded Screening Levels for zinc, iron, cadmium or combinations of these metals, sulfate, and the VOCs cis-1,2-dichlorethene and trichloroethene. Finally, three residue stockpiles or groupings of piles were identified as PAOCs based on the occurrence of TCLP lead at concentrations above the RCRA hazardous waste threshold.

B. HHRA

The results of the Tier 1 HHRA indicated that with one exception, all cumulative Tier 1 level hazard indices (T1HI) are below the target level of 1, indicating little, if any, potential for adverse non-cancer health effects associated with the Site. Two sediment samples collected immediately south and southwest of the Site boundary contained levels of lead in excess of the highly conservative screening level (400 mg/kg), which is based on daily exposure of a young child to soil rather than occasional contact with aquatic sediment. Because the area of affected sediment is very limited and the Tier 1 screening level is based on a much more intensive exposure regime than could occur by occasional contact with sediment, the fact that individual sample results exceed a residential screening level for lead does not necessarily indicate that there is an elevated risk associated with lead in sediment.

The only T1CRs greater than the target level of 10^{-6} were (1) 4×10^{-6} computed for the On-Site Commercial/Industrial Worker, due entirely to potential exposure to arsenic in surface soil, and (2) 3×10^{-6} computed for the off-Site Resident due to potential exposure to trichloroethylene in potable

³¹ As discussed in Section III, most of the cadmium exceedances were for concentrations in XRF screening samples estimated using a site-wide zinc/cadmium ratio.

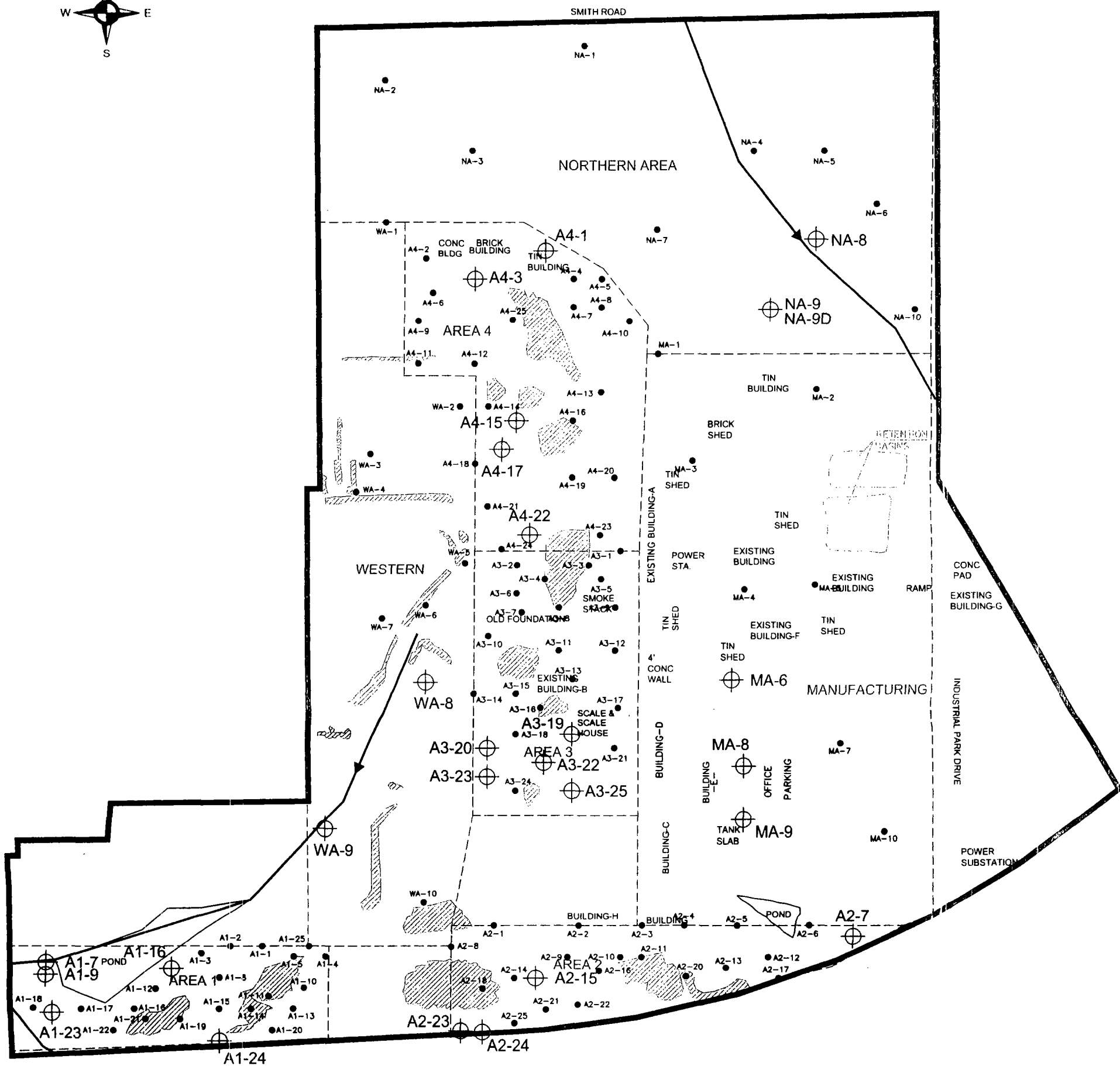
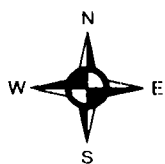
water from Lake Hillsboro when the upper bound of the proposed draft slope factor range is used. The representative concentration of arsenic (7.9 mg/kg) is below the Illinois background level (11.3 mg/kg), and arsenic was not used as a raw material and was not a product of Site operations. The detection-level value used as the representative concentration of trichloroethylene in Lake Hillsboro was obtained from a sampling location close to the Site, and as such does not represent conditions in Lake Hillsboro. Further, this water is seldom used for potable purposes and surface water samples collected from the reservoir by IEPA near the potable water intake in 2001 contained no constituent concentrations above federal MCLs. Thus, these slight exceedances of the lower bound of EPA's target cancer risk range are not interpreted as suggestive of an unacceptable risk to human health.

The majority of assumptions involved in developing Tier 1 screening levels and representative concentrations are deliberately conservative, tending to overestimate exposure. As a result, the cumulative TICRs/TIHI for the defined receptor populations at the Site are likely to overstate potential risks/hazards. Because none of the cumulative TICRs/TIHI exceeded target levels for either carcinogenic or non-carcinogenic effects (except for soil-associated arsenic, which is not Site-related), the available data support the conclusion that under current and reasonably anticipated future conditions, COPCs associated with the Site pose no significant cancer risk or non-carcinogenic hazard to the receptor populations considered in the HHRA. This conclusion comports with that reached by the Illinois Department of Public Health (IDPH) in its recent health consultation for this Site (IDPH 2002; included herein as Appendix VI-3). The IDPH health consultation was prepared before initiation of data collection activities for the RI/FS and the RI/FS risk assessments.

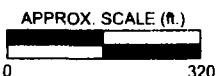
C. ERSE

The SLERA portion of the ERSE assessed the risks to wildlife that may be exposed to Site-related constituents in the surface water, sediment, and soil at and near the Site (but not direct exposure to the residue piles). The wildlife that was assessed in the SLERA were aquatic wildlife, fish-eating wildlife (piscivores), and terrestrial wildlife. As required in a screening level assessment, the assessment of risks was conducted in a very conservative (i.e., protective) manner for each medium/wildlife combination. The outcome of the SLERA was that no significant risk was predicted for some of the medium/wildlife combinations, while others needed further evaluation. Consistent with USEPA guidance, these medium/wildlife combinations that needed further evaluation were carried forward into the BERA.

The BERA portion of the evaluation assessed the potential risks that were not "screened out" in the SLERA, but evaluated them in a less conservative but still protective manner. Specifically consistent with USEPA guidance, the risk estimates took into account more realistic exposure and toxicity information. This means that the BERA (unlike the SLERA) did not assume consistent



LEGEND	
	SITE BOUNDARY
	STREAMS/DRAINAGE
	FLOW DIRECTION
	SITE AREAS
	RESIDUE PILES
	RAILROAD
	SOIL SAMPLE LOCATION
	SOIL BORING - SAMPLE NOT SENT TO LAB



ENVIRON

SOIL SAMPLE LOCATIONS
EAGLE ZINC
HILLSBORO, ILLINOIS

Figure
VII-5c

Drafter: APR

Date: 10/27/04

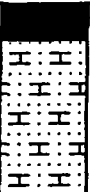
Contract Number:

21-7400E

APPROVED:

REVISED:

157

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A1-1 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/16/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macrosampler HAMMER WT./DROP: --				
SURVEY LOCATION: E694717.8 N908219					GROUND SURFACE ELEVATION: - N/A -				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0-4	4.0		0	0			0.8 4.0	RESIDUE: Residue SILTY CLAY: Silty clay, brown, some sand, moist.	

ENVIRON

740 Waukegan Rd., Suite 401
Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A1-2

TOTAL DEPTH: 8 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/16/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macrosampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 694537.8 N 988249

GROUND SURFACE ELEVATION: 614.62'

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PII (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
------------------	-----------------	-----------	-----------	------------	-------------	------	------------------	------------------

0-4	4.0		0	0			2.0	RESIDUE: Residue
4-8	4.0		0	-5				SILTY CLAY: Silty clay, brown.

ENVIRON

740 Waukegan Rd., Suite 401
Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A1-3

TOTAL DEPTH: 12 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/15/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macrosampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 694455.2 N 908228.8

GROUND SURFACE ELEVATION: 605.75'

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0		0	0				RESIDUE: Residue
4-8	4.0		0	-5				
8-12	4.0		0	-10			7.0	SILTY CLAY: Silty Clay, brown, some sand lenses, stiff, moist.

ENVIRON

740 Waukegan Rd., Suite 401
Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A1-4


TOTAL DEPTH: 4 feet

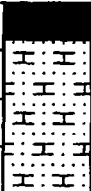
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/16/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macrosampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 694807.8 N 908219

GROUND SURFACE ELEVATION: 620.78'

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0-4	4.0		0				1.5	RESIDUE: Residue SILTY CLAY: Silty clay, brown, some sand, moist.

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A1-5 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/16/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macrosampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 694717.8 N 908219					GROUND SURFACE ELEVATION: N/A				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0-4	4.0		0	0			0.8 4.0	RESIDUE: Residue SILTY CLAY: Silty clay, brown, some sand, moist.	

ENVIRON

740 Waukegan Rd., Suite 401
Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A1-6

TOTAL DEPTH: 12 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillshire, IL
JOB NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/15/02


DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macrosampler
HAMMER WT/DROP: --

SURVEY LOCATION: E 694371 N 908184.3

GROUND SURFACE ELEVATION: 600.39'

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	1.0		0	0				RESIDUE: Residue
4-8	1.5		0	-5				
8-12	4.0			-10				SILTY CLAY: Silty clay, brown mottling, trace sand, medium stiff, moist.

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A1-7 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/15/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 694014.6 N 908202.6					GROUND SURFACE ELEVATION: N/A				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0-4	4.0		0	0			1.5	RESIDUE: Residue CLAYEY SILT: Clayey silt, brown, moist.	

740 Waukegan Rd., Suite 401
Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A1-8

TOTAL DEPTH: 4 feet

PROJECT:	Eagle Zinc
SITE LOCATION:	Hillsboro, IL
JOB NO.:	21-7400E
LOGGED BY:	J. Fraser, C. Greco
DATES DRILLED:	07/16/02

DRILLING CO.:	Phillips
RIG TYPE:	Direct Push
METHOD OF DRILLING:	Geoprobe
SAMPLING METHODS:	Macro-core Sampler
HAMMER WT./DROP	--

SURVEY LOCATION: E 964807.8, N 908219

GROUND SURFACE ELEVATION: 620.78'

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0	0		0	RESIDUE: Residue
				1.0	SILTY CLAY: Silty clay.

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A1-9 TOTAL DEPTH: 8 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/16/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 694014.7, N 908167.2					GROUND SURFACE ELEVATION: 593.17'				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0-4	4.0		0	0			3.0	RESIDUE: Residue.	
4-8	4.0		0	-5				SILTY CLAY: Silty clay, brown.	

ENVIRON

740 Waukegan Rd. Suite 401
Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A1-10

TOTAL DEPTH: 4 feet


PROJECT: Eagle Zinc
SITE LOCATION: Hillside, IL
JOB NO.: 21-7400F
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/15/02

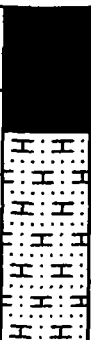
DRILLING CO: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macrosampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 694627.8 N 908249

GROUND SURFACE ELEVATION: 616.38'

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
------------------	-----------------	-----------	-----------	------------	-------------	------	------------------	------------------

0-4	4.0		0	0			2.0	RESIDUE: Residue SILTY CLAY: Silty clay, brown, moist.
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<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A1-11 TOTAL DEPTH: 4.0			
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/15/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --			
SURVEY LOCATION: E 694647.9, N 908105.2					GROUND SURFACE ELEVATION: 619.51			
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0.4	4.0		0				1.5	RESIDUE: Residue SILTY CLAY: Silty clay, brown, moist.

ENVIRON

740 Waukegan Rd., Suite 401
Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A1-12

TOTAL DEPTH: 7 feet


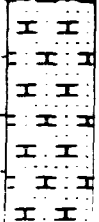
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/15/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macrosampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 694327.4 N 908126.8

GROUND SURFACE ELEVATION: 613.58'

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
------------------	-----------------	-----------	-----------	------------	-------------	------	------------------	------------------

0-1	1.0		0	0			0	RESIDUE: Residue, Stained residue, clay fill, black from 2.0 to 3.0 ft.
4-8	1.5		0	3.0			3.0	SILTY CLAY: Silty clay, grey, orange-brown mottling, trace sand, stiff, moist.

ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015					GEOLOGIC DRILL LOG BOREHOLE NO.: A1-13 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/16/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macrosampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 694717.8 N 908069					GROUND SURFACE ELEVATION: 612.72'				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0-4	4.0		0	0			2.0	SILTY CLAY: Silty clay, grey mottling, some sand, moist. SILTY CLAY: Silty clay, orange-brown mottling, some sand, moist.	

ENVIRON

740 Waukegan Rd., Suite 401
Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A1-14

TOTAL DEPTH: 8.0

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/16/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 694597.8, N 908069

GROUND SURFACE ELEVATION: 620.18

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0		0	0				RESIDUE: Residue
4-8	4.0		0	-5			5.0	SILTY CLAY: Silty clay, brown, moist, stiff.
							8.0	

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GEOLOGIC DRILL LOG

PROJECT:	Eagle Zinc
SITE LOCATION:	Hillsboro, IL
JOB NO.:	21-7400E
LOGGED BY:	J. Fraser, C. Greco
DATES DRILLED:	07/16/02

DRILLING CO.:	Philips
RIG TYPE:	Direct Push
METHOD OF DRILLING:	Geoprobe
SAMPLING METHODS:	Macro-core Sampler
HAMMER WT./DROP	--

SURVEY LOCATION: E 694507.8, N 908069

GROUND SURFACE ELEVATION:616.86

LOSS INTERVAL (ft)	LOSS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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			0		RESIDUE: Residue
0-4	4.0	0			
4-8	4.0	0			
8-12	4.0	0		9.0	SILTY CLAY: Silty clay, some sand, grey, orange-brown mottling, moist, stiff.

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A1-16

TOTAL DEPTH: 11 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/15/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT/DROP: --

SURVEY LOCATION: E 695584, N 908178.4

GROUND SURFACE ELEVATION: 631.23

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PII (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0-1	1.0		0	0				RESIDUE: Residue
4-8	1.5		0	-5				
8-12	4.0		0	-10			9.0	SILTY CLAY: Silty clay, brown, dry, trace sand, stiff.
				-11.0			11.0	

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A1-17

TOTAL DEPTH: 8 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/15/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 696094 N 908157.4

GROUND SURFACE ELEVATION: 625.28'

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0		0	0				RESIDUE: Residue
4-8	4.0		0	-5			5.0	CLAYEY SILT: Silty clay, brown, trace sand.

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A1-18

TOTAL DEPTH: 28 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/15/02

DRILLING CO: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macrosampler
HAMMER WT DROP: --

SURVEY LOCATION: E693981.6 N988871.6

GROUND SURFACE ELEVATION: --

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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				0				RESIDUE Residue to end of boring at -28 ft
0-4	4							
4-8	4			-5				
8-12	4			-10				
12-16	4			-15				
16-20	4			-20				
20-24	4			-25				
24-28	4							
							28	

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A1-19 TOTAL DEPTH: 16 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400F LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/16/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT/DROP: --				
SURVEY LOCATION: E 694396.5, N 908039.2					GROUND SURFACE ELEVATION: 618.23'				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0-4	4.0		0				RESIDUE: Residue		
4-8	4.0		0						
8-12	4.0		0						
12-16	4.0		0			11.5	SILTY CLAY: Silty clay, brown, some sand.		

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A1-20

TOTAL DEPTH: 4 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/15/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macrosampler
HAMMER WT./DROP: --

SURVEY LOCATION: E694657.8 N908009

GROUND SURFACE ELEVATION: 611.39

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0		0				0.5	SANDY SILT: Sandy silt, lt brown, moist
			0				4.0	SANDY CLAY: Sandy clay, lt brown

<h1 style="text-align: center;">ENVIRON</h1> <p style="text-align: center;">740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015</p>				<h2 style="text-align: center;">GEOLOGIC DRILL LOG</h2> <p style="text-align: center;">BOREHOLE NO.: A1-21 TOTAL DEPTH: 28 feet</p>				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/16/02				DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 694207.8, N 908009				GROUND SURFACE ELEVATION: 616.29'				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION

				0				RESIDUE: Residue, water at 22' to 24'.
0-4	4.0		0					
4-8	4.0		0	-5				
8-12	4.0		0	-10				
12-16	4.0		0	-15				
16-20	4.0		0	-20				
20-24	4.0		0	-25				
24-28	4.0							

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A1-22
TOTAL DEPTH: 28 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/16/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E694207.8 N900009

GROUND SURFACE ELEVATION: 616.29

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
------------------	------------------	-----------	-----------	------------	-------------	------	------------------	------------------

				0				RESIDUE: Residue, water at 22 to 24'
0-4	4.0		0					
				-5				
4-8	4.0		0					
				-10				
8-12	4.0		0					
				-15				
12-16	4.0		0					
				-20				
16-20	4.0		0					
				-25				
20-24	4.0		0					
				-28				
24-28	4.0							
							28	

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A1-23

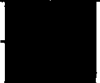
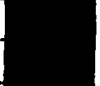
TOTAL DEPTH: 8 feet

PROJECT:	Eagle Zinc
SITE LOCATION:	Hillsboro, IL
JOB NO.:	21-7400E
LOGGED BY:	J. Fraser, C. Greco
DATES DRILLED:	07/16/02

DRILLING CO.:	Phillips
RIG TYPE:	Direct Push
METHOD OF DRILLING:	Geoprobe
SAMPLING METHODS:	Macro-core Sampler
HAMMER WT/DROP	--

SURVEY LOCATION: E 694035, N 908058.4

GROUND SURFACE ELEVATION: 607.29'

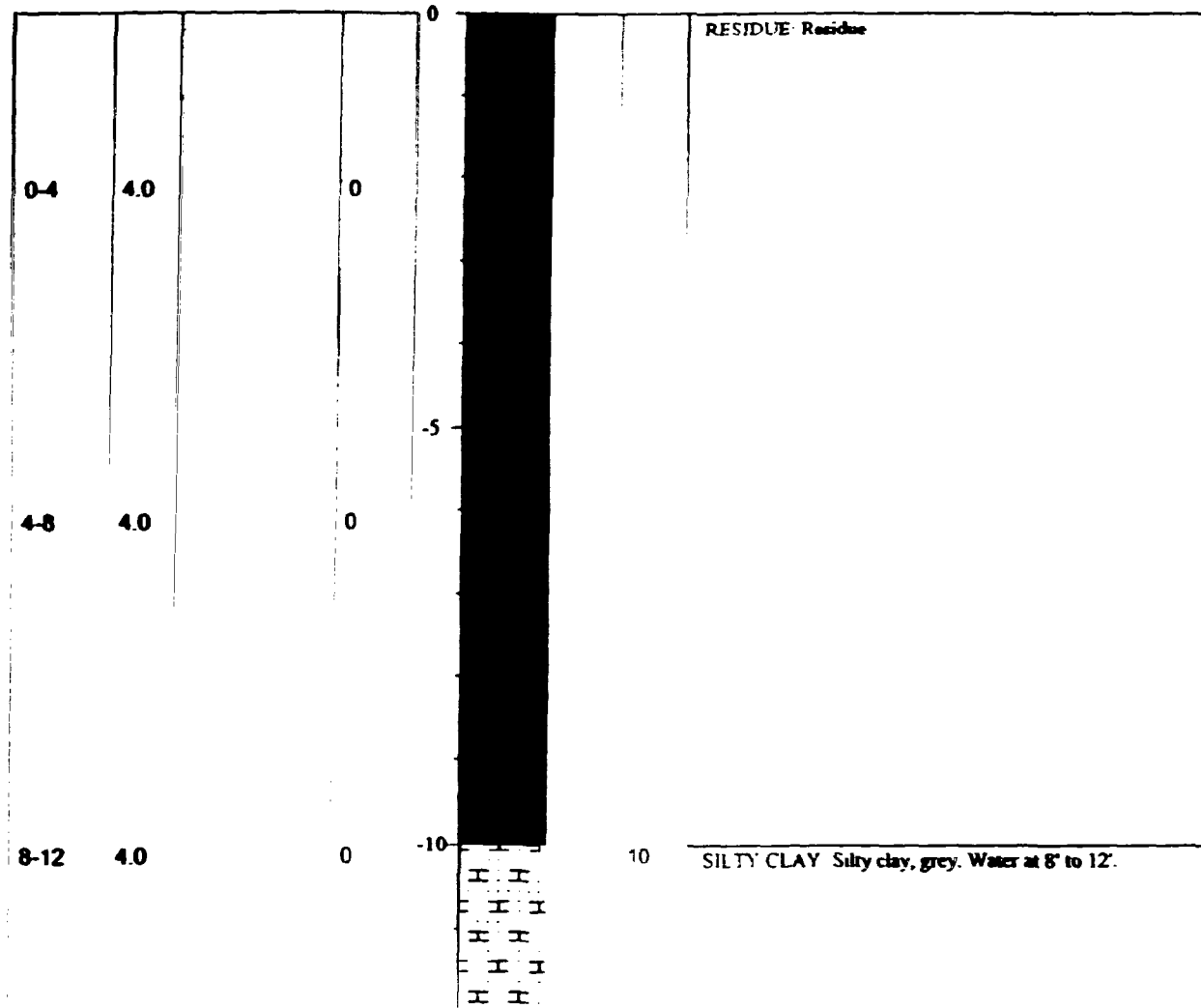
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0-4	4.0		0	0			6.0	RESIDUE: Residue.
4-8	4.0		0	5				SILTY CLAY: Silty clay, brown, some sand, moist, stiff.

ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015	GEOLOGIC DRILL LOG BOREHOLE NO.: A1-24 TOTAL DEPTH: 12 feet
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PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/16/02	DRILLING CO: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT DROP: --
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SURVEY LOCATION: E 694507.8, N 907979	GROUND SURFACE ELEVATION: 606.79'
--	--

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A1-25 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/16/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 694760.7, N908248.3					GROUND SURFACE ELEVATION: 616.38'				
SS INTERVAL (R)	SS RECOVERY (R)	SAMPLE ID	PID (ppm)	DEPTH (R)	GRAPHIC LOG	USCS	LAYER DEPTH (R)	SOIL DESCRIPTION	
0-4	4.0		0	0				SILTY CLAY: Silty Clay, brown with orange-brown mottling, moist, stiff, some sand.	

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A2-1

TOTAL DEPTH: 8 feet

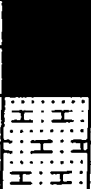
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 695284 N 908307.4

GROUND SURFACE ELEVATION: 628.69

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4		0	0				RESIDUE: Residue
4 - 8	4		0	4			6	SILTY CLAY Silty clay, gray brown

<div style="border: 2px solid black; padding: 5px; display: inline-block; font-size: 2em; font-weight: bold; letter-spacing: 0.5em;">E N V I R O N</div> <p>740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015</p>					GEOLOGIC DRILL LOG BOREHOLE NO.: A2-2 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/18/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 695584 N 908307.4					GROUND SURFACE ELEVATION: 629.92				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0 0	0		2	RESIDUE: Residue SILTY CLAY: Silty clay, gray with orange-brown, moist		

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A2-3


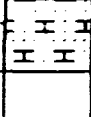
TOTAL DEPTH: 4 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 695704 N 908307.4

GROUND SURFACE ELEVATION: 631.11

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	3		0	0			1.5	RESIDUE: Residue SILTY CLAY: Silty clay, orange-brown mottled
			0					

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A2-4

TOTAL DEPTH: 8 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 695824 N908307.4

GROUND SURFACE ELEVATION: 631.41

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0 - 4	4			0				RESIDUE: Residue
4 - 8	4		0	-5			4.2 4.5	SILTY CLAY: Silty clay, black SILTY CLAY: Silty clay, orange-brown mottled

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A2-5

TOTAL DEPTH: 8 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
NR NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 695374 N908307.4

GROUND SURFACE ELEVATION: 629.22

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0 - 4	4			0				RESIDUE. Residue
							3.5	SILTY CLAY: Silty clay, black to dk gray, changing to gray at -4.5 ft (soft)
4 - 8	4		0				5	SILTY CLAY: Silty clay, orange-brown mottled

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BOREHOLE NO.: **A2-6**
TOTAL DEPTH: **4 feet**


PROJECT:	Eagle Zinc
SITE LOCATION:	Hillsboro, IL
JOB NO.:	21-7400E
LOGGED BY:	J. Fraser, C. Greco
DATES DRILLED:	7/18/02

DRILLING CO.:	Philips
RIG TYPE:	Direct Push
METHOD OF DRILLING:	Geoprobe
SAMPLING METHODS:	Macro-core Sampler
HAMMER WT./DROP	--

SURVEY LOCATION: E 696179.3 N 908307.9

GROUND SURFACE ELEVATION:627.56

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0 - 4	4	0	0		1.5	SILTY CLAY: Silty clay, partly organic, dk brown SILTY CLAY: Silty clay, trace sand, brown, moist
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GEOLOGIC DRILL LOG

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400F
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02


DRILLING CO.: Philips
 RIG TYPE: Direct Push
 METHOD OF DRILLING: Geoprobe
 SAMPLING METHODS: Macro-core Sampler
 HAMMER WT./DROP: --

SURVEY LOCATION: E 696304 N 908277.4

GROUND SURFACE ELEVATION: 623.85

SS INTERVAL (ft)
SS RECOVERY (%)
SAMPLE ID
PID (ppm)
DEPTH (ft)
GRAPHIC LOG
USCS
LAYER DEPTH (ft)
SOIL DESCRIPTION

0-4	4	0	0	0.5	1	RESIDUE: Residue
		0				SILTY CLAY: Silty clay, black
						SILTY CLAY: Silty clay, brown mottled, moist

<h1 style="margin: 0;">ENVIRON</h1> <p style="margin: 0;">740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015</p>					<h2 style="margin: 0;">GEOLOGIC DRILL LOG</h2> <p style="margin: 0;">BOREHOLE NO.: A2-8 TOTAL DEPTH: 8 feet</p>				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/18/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 695164 N 908247.4					GROUND SURFACE ELEVATION: 628.68				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4			0			5.5 0	RESIDUE: Residue with silt layers	
4 - 8	4		0 0			SILTY CLAY: Silty clay, black, soft SILTY CLAY: Silty clay, gray and orange mottled			

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A2-9

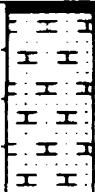
TOTAL DEPTH: 4 feet

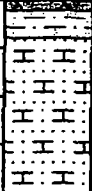
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT/DROP: --

SURVEY LOCATION: E 695494 N 988217.4

GROUND SURFACE ELEVATION: 626.61

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0-4	4		0 0	0 0.2			0.2	RESIDUE. Residue SILTY CLAY: Silty clay, brown and orange mottled

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A2-10 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/18/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 695644 N 908217.4					GROUND SURFACE ELEVATION: 629.1				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0 0	0			0.2 1	TOPSOIL: Sandy topsoil, black SILT: Silt, brown, dry SILTY CLAY: Silty clay, gray and orange-brown mottled	

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A2-11

TOTAL DEPTH: 4 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
NRI NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/82

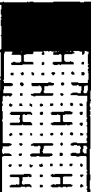
DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 695704 N 908217.4

GROUND SURFACE ELEVATION: 630.41

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
------------------	-----------------	-----------	-----------	------------	-------------	------	------------------	------------------

0 - 4	4		0	0			1	RESIDUE: Residue
							2	SILTY CLAY: Silty clay, black and brown
								SILTY CLAY: Silty clay, trace sand, gray and orange-brown mottled

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A2-12 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/18/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 696064 N 908217.4					GROUND SURFACE ELEVATION: 624.7				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0				1	RESIDUE: Residue SILTY CLAY: Silty clay, brown, slightly mottled	

ENVIRON

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Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A2-13

TOTAL DEPTH: 4 feet

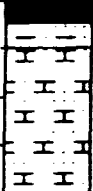
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400Z
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 695944 N 908187.4

GROUND SURFACE ELEVATION: 625.69

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
------------------	-----------------	-----------	-----------	------------	-------------	------	------------------	------------------

0 - 4	4		0	0			0.5 1	RESIDUE: Residue CLAYEY SILT: Clayey silt, gray (dry) SILTY CLAY: Silty clay, brown mottled
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ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015					GEOLOGIC DRILL LOG BOREHOLE NO.: A2-14 TOTAL DEPTH: 8 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/18/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT/DROP: --				
SURVEY LOCATION: E 695944 N 908157.4					GROUND SURFACE ELEVATION: 625.21				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4			0			4.5	RESIDUE: Residue with silt layers	
4 - 8	4		0	0				SILTY CLAY: Silty clay, trace sand, gray and orange-brown mottled	

ENVIRON

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Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A2-15

TOTAL DEPTH: 4 feet


PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT/DROP: --

SURVEY LOCATION: E 695404 N900157.4

GROUND SURFACE ELEVATION: 626.07

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0 - 4	4		0	0			2	RESIDUE: Residue SILTY CLAY. Silty clay, some sand, brown mottled, moist
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ENVIRON

740 Waukegan Rd., Suite 401
Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A2-16

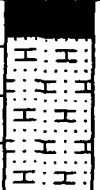
TOTAL DEPTH: 4 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP --

SURVEY LOCATION: E 695584 N 908178.4

GROUND SURFACE ELEVATION: 631.23

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4		0 0	0			0.8	RESIDUE: Residue with silt layers SILTY CLAY: Silty clay, brown and orange mottled

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A2-17

TOTAL DEPTH: 4 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 696094 N900157.4

GROUND SURFACE ELEVATION: 625.28

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4		0 0	0	H H H H H H H H H H		0.5	SILTY CLAY: Silty clay, partly organic, dk. brown SILTY CLAY: Silty clay, olive brown, slightly mottled

<div style="border: 2px solid black; padding: 5px; display: inline-block; font-size: 2em; font-weight: bold; letter-spacing: 0.5em;">ENVIRON</div> <p>740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015</p>					GEOLOGIC DRILL LOG BOREHOLE NO.: A2-18 TOTAL DEPTH: 8 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/18/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 695254 N 908127.4					GROUND SURFACE ELEVATION: 623.18				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4			0			1	RESIDUE: Residue	
4 - 8	4		0	0		4.5	SILTY CLAY: Silty clay, dk brown		
								SILTY CLAY: Silty clay, orange-brown mottled	

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A2-19

TOTAL DEPTH: 4 feet

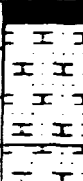
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400Z
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT/DROP: --

SURVEY LOCATION: E 695164 N 908997.4

GROUND SURFACE ELEVATION: 623.91

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4		0		0.5	RESIDUE: Residue
						SILTY CLAY: Silty clay, gray
			0		3	SILTY CLAY: Silty clay, orange-brown mottled

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A2-20 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/18/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 695830.9 N908163					GROUND SURFACE ELEVATION: 629.14				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0	0			.8	RESIDUE: Residue SILTY CLAY: Silty clay, orange-brown mottled	

ENVIRON

740 Waukegan Rd., Suite 401
Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A2-21

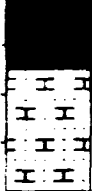
TOTAL DEPTH: 4 feet

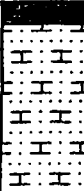
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 695434 N 988867.4

GROUND SURFACE ELEVATION: 625.18

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4		0	0			1.5	RESIDUE. Residue SILTY CLAY: Silty clay, some sand, gray and orange-brown mottling, moist

<div style="border: 2px solid black; display: inline-block; padding: 5px 20px; font-weight: bold; font-size: 1.5em;">ENVIRON</div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A2-22 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/18/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 695524 N 908081.7					GROUND SURFACE ELEVATION: 624.3				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0 0	0			0.5	SANDY CLAY: Sandy clay, brown SILTY CLAY: Silty clay, gray and orange-brown mottled	

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A2-23

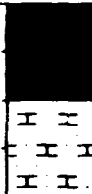
TOTAL DEPTH: 4 feet

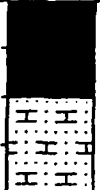
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 695194 N 983007.4

GROUND SURFACE ELEVATION: 620.81

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4		0 0	0			2	RESIDUE: Residue SILTY CLAY: Silty clay, brown mottled

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A2-24 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/18/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT/DROP: --				
SURVEY LOCATION: E 695254 N 908004.3					GROUND SURFACE ELEVATION: 622.26				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0 0				2	RESIDUE: Residue SILTY CLAY: Silty clay, brown	

ENVIRON

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Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A2-25

TOTAL DEPTH: 4 feet

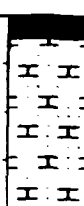
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-74002
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO. Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP --


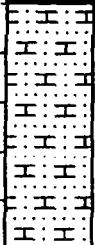
SURVEY LOCATION: E 695345 N 900028.9

GROUND SURFACE ELEVATION: 623.6

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0 - 4	4		0	0			0.5	SANDY CLAY: Sandy clay, brown SILTY CLAY: Silty clay, gray
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<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A3-1 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/19/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695636.4 N909366.7					GROUND SURFACE ELEVATION: 632.35				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0 0	0			1 2 4	RESIDUE: <i>Residue</i> SILTY CLAY: Silty clay, gray SILTY CLAY: Silty clay, brown	

<div style="border: 2px solid black; padding: 5px; display: inline-block; font-size: 2em; font-weight: bold; letter-spacing: 0.5em;">E N V I R O N</div> <p>740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015</p>					GEOLOGIC DRILL LOG BOREHOLE NO.: A3-3 TOTAL DEPTH: 8 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/19/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT/DROP: --				
SURVEY LOCATION: E695546.4 N909326.5					GROUND SURFACE ELEVATION: 631.0				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0 0	0			3	RESIDUE: Residue SILTY CLAY: Silty clay, gray and brown	
4 - 8	4			-5					

ENVIRON

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Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A3-4

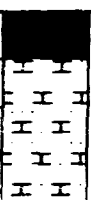
TOTAL DEPTH: 4 feet

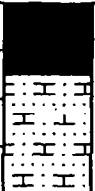
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT/DROP: --

SURVEY LOCATION: E696422.4 N909286.7

GROUND SURFACE ELEVATION: 629.84

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4		0 0	0			1	RESIDUE: Residue SILTY CLAY: Silty clay, brown

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A3-5 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/19/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695582.4 N909286.7					GROUND SURFACE ELEVATION: 631.51				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0				1.5	RESIDUE: Residue	
			0				4	SILTY CLAY: Silty clay, brown to gray	

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Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

PROJECT:	Eagle Zinc
SITE LOCATION:	Hillsboro, IL
JOB NO.:	21-7400E
LOGGED BY:	J. Fraser, C. Greco
DATES DRILLED:	7/18/02

DRILLING CO.:	Philips
RIG TYPE	Direct Push
METHOD OF DRILLING:	Geoprobe
SAMPLING METHODS:	Macro-core Sampler
HAMMER WT./DROP	--

SURVEY LOCATION: E695342.4 N909246.7

[illegible]

0-4	4	0	0	0	SILTY CLAY. Silty clay, brown to gray
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<div style="border: 2px solid black; padding: 5px; display: inline-block; font-weight: bold; font-size: 1.5em; margin-bottom: 5px;">E N V I R O N</div> <p>740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015</p>					<p>GEOLOGIC DRILL LOG</p> <p>BOREHOLE NO.: A3-7</p> <p>TOTAL DEPTH: 12 feet</p>				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/20/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695357.1 N909193.5								GROUND SURFACE ELEVATION: ---	
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4			0			9	RESIDUE: Residue	
4 - 8	4			-5					
8 - 12	4		0 0	-10			12	SILTY CLAY: Silty clay, gray	

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A3-8

TOTAL DEPTH: 8 feet

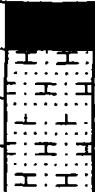
PROJECT	Eagle Zinc	DRILLING CO	Philips
SITE LOCATION	Hillsboro, IL	RIG TYPE	Direct Push
JOB NO	21-7400E	METHOD OF DRILLING	Geoprobe
LOGGED BY	J. Fraser, C. Greco	SAMPLING METHODS	Macro-core Sampler
DATES DRILLED	7/20/02	HAMMER WT./DROP	--

SURVEY LOCATION: E695462.4 N99206.7

GROUND SURFACE ELEVATION: 632.78

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0 - 4	4			0				RESIDUE Residue
4 - 8	4		0	-5			4	SILTY CLAY. Silty clay, brown
			0				8	

ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015					GEOLOGIC DRILL LOG BOREHOLE NO.: A3-9 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/20/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695622.4 N909206.7					GROUND SURFACE ELEVATION: 633.27				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0 0	0 4			1 4	RESIDUE: Residue SILTY CLAY: Silty clay, brown	

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A3-10

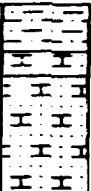
TOTAL DEPTH: 4 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E695262.4 N909126.7

GROUND SURFACE ELEVATION: --

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4		0				1 1.5	SILT: Sandy silt, organic, black SILTY CLAY: Silty clay, black SILTY CLAY: Silty clay, gray and orange-brown mottled

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A3-11


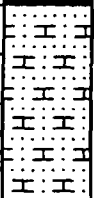
TOTAL DEPTH: 8 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/20/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E695462.5 N909086.7

GROUND SURFACE ELEVATION: 632.82

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4			0			4	RESIDUE: Residue
4 - 8	4		0	-5			8	SILTY CLAY: Silty clay, brown and gray

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A3-12

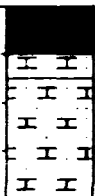
TOTAL DEPTH: 4 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400F
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/20/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E695622.5 N909086.6

GROUND SURFACE ELEVATION: 634.61

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4		0 0	0			1 1.5 4	RESIDUE: Residue SILTY CLAY: Silty clay, trace residue SILTY CLAY: Silty clay, brown

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BOREHOLE NO.: **A3-13**
TOTAL DEPTH: **8 feet**

PROJECT:	Eagle Zinc
SITE LOCATION:	Hillsboro, IL
JOB NO.:	21-7400E
LOGGED BY:	J. Fraser, C. Greco
DATES DRILLED:	7/18/02

DRILLING CO.:	Phillips
RIG TYPE:	Direct Push
METHOD OF DRILLING:	Geoprobe
SAMPLING METHODS:	Macro-core Sampler
HAMMER WT./DROP	--

SURVEY LOCATION: E695502.4 N909006.7

GROUND SURFACE ELEVATION:—

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0 - 4	4				RESIDUE: Residue
4 - 8	4		0 0	-4.5	SILTY CLAY: Silty clay, gray and orange-brown mottled

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A3-14

TOTAL DEPTH: 4 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT/DROP: --

SURVEY LOCATION: E 695222.5 N 900966.7

GROUND SURFACE ELEVATION: 624.18

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0 - 4	4		0				0.5	SANDY CLAY: Sandy clay
			0				1	SILTY CLAY: Silty clay, yellow brown
								SILTY CLAY: Silty clay, trace sand, brown

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A3-15 TOTAL DEPTH: 8 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/20/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695342.4 N908966.7					GROUND SURFACE ELEVATION: 624.58				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0	0			1	RESIDUE: Residue, red and beige	
							3	SILTY CLAY: Silty clay, brown	
							4	RESIDUE: Residue	
4 - 8	4		0	0			8	SILTY CLAY: Silty clay, brown	

ENVIRON

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Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A3-16

TOTAL DEPTH: 8 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/20/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E695412.4 N988926.6

GROUND SURFACE ELEVATION: 631.42

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4			0				RESIDUE: Residue
4 - 8	4		0	5			5	SILTY CLAY: Silty clay, brown
			0	8			8	

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A3-17 TOTAL DEPTH: 8 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/20/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695633.4 N908926.7					GROUND SURFACE ELEVATION: 634.78				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4			0			4	RESIDUE: Residue	
4 - 8	4		0	0		8	SILTY CLAY: Silty clay, brown and gray		

ENVIRON

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Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: A3-18

TOTAL DEPTH: 4 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/19/02


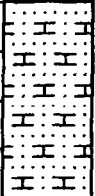
DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT DROP: --

SURVEY LOCATION: E695342.4 N988346.7

GROUND SURFACE ELEVATION: 628.71

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PIU (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0 - 4	4		0					RESIDUE Residue
			0					SILTY CLAY: Silty clay, gray and orange-brown mottled

<div style="font-size: 2em; font-weight: bold; letter-spacing: 0.5em;">ENVIRON</div> <div style="font-size: 0.8em; margin-top: 5px;">740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015</div>					<div style="font-size: 1.2em; font-weight: bold;">GEOLOGIC DRILL LOG</div> <div style="font-size: 0.9em; margin-top: 5px;">BOREHOLE NO.: A3-19 TOTAL DEPTH: 8 feet</div>				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/20/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695502.4 N908846.7							GROUND SURFACE ELEVATION: 634.3		
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4			0			4	RESIDUE: Residue	
4 - 8	4		0	0			8	SILTY CLAY: Silty clay, brown	

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A3-20

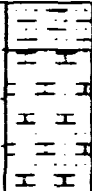
TOTAL DEPTH: 4 feet

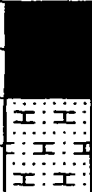
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/19/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT: DROP --

SURVEY LOCATION: E695262.4 N988806.7

GROUND SURFACE ELEVATION: 625.92

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4		0 0	0			1 4	SANDY SILT Gray sandy silt SILTY CLAY Silty clay, gray and orange-brown mottled

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					<div style="text-align: center;"> GEOLOGIC DRILL LOG BOREHOLE NO.: A3-21 TOTAL DEPTH: 4 feet </div>				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/18/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695622.4 N908806.7					GROUND SURFACE ELEVATION: 634.46				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0 0	0			2 4	RESIDUE: Residue SILTY CLAY: Silty clay, brown mottled	

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A3-22

TOTAL DEPTH: 8 feet

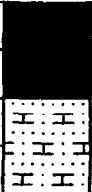
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
NR NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/20/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E695422.4 N908766.7

GROUND SURFACE ELEVATION: 633.49

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4			0			4	RESIDUE: Residue
4 - 8	4		0	-5			8	SILTY CLAY. Silty clay, brown

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A3-23 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/19/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695262.4 N908726.7					GROUND SURFACE ELEVATION: 624.58				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0 0	0			2 4	RESIDUE: Residue SILTY CLAY: Silty clay, mottled brown	

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: **A3-24**

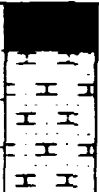
TOTAL DEPTH: **4 feet**

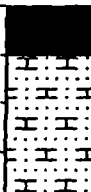
PROJECT: **Eagle Zinc**
SITE LOCATION: **Hillsboro, IL**
JOB NO: **21-7400E**
LOGGED BY: **J. Fraser, C. Greco**
DATES DRILLED: **7/20/02**

DRI LING CO: **Philips**
RIG TYPE: **Direct Push**
METHOD OF DRILLING: **Geoprobe**
SAMPLING METHODS: **Macro-core Sampler**
HAMMER WT./DROP: **--**

SURVEY LOCATION: **E695342.4 N908686.7**

GROUND SURFACE ELEVATION: **624.79**

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4		0 0	0			1 4	RESIDUE <i>Residue</i> SILTY CLAY: <i>Silty clay, brown</i>

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					<div style="text-align: center;"> GEOLOGIC DRILL LOG BOREHOLE NO.: A3-25 TOTAL DEPTH: 4 feet </div>				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/18/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT/DROP: --				
SURVEY LOCATION: E 695502.4 N 908686.7					GROUND SURFACE ELEVATION: 631.79				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0				1	RESIDUE: Residue SILTY CLAY: Silty clay, orange-brown mottled	

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A4-1

TOTAL DEPTH: 8 feet


PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/19/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E695417.9 N910212.5

GROUND SURFACE ELEVATION: 632.11

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PIID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4			0			3	RESIDUE Residue
4 - 8	4		0	-5			8	SILTY CLAY Silty clay, gray and orange-brown mottled

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A4-2 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/18/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695078.4 N910189.6					GROUND SURFACE ELEVATION: 634.32				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0				1.5 2.5 4	RESIDUE: Residue SANDY CLAY: Sandy clay, gray SILTY CLAY: Silty clay, gray and brown mottled	

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A4-3

TOTAL DEPTH: 4 feet


PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/19/02

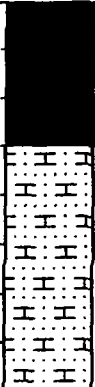
DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E695217.9 N910132.5

GROUND SURFACE ELEVATION: 633.5

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4		0	0			1	RESIDUE: Residue
			0				4	SILTY CLAY: Silty clay, gray and orange-brown mottled

<u>ENVIRON</u> 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015					GEOLOGIC DRILL LOG BOREHOLE NO.: A4-4 TOTAL DEPTH: 8 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/20/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695497.9 N910132.5					GROUND SURFACE ELEVATION: 631.7				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0	0			3	RESIDUE: Residue	
4 - 8	4		0	0			8	SILTY CLAY: Silty clay, gray to brown	

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A4-5

TOTAL DEPTH: 4 feet

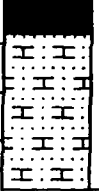
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/20/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E695577.9 N910132.5

GROUND SURFACE ELEVATION: 630.59

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	0			0			4	No recovery

ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015					GEOLOGIC DRILL LOG BOREHOLE NO.: A4-6 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/18/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695097.9 N910092.5					GROUND SURFACE ELEVATION: 634.02				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0				0.8	RESIDUE: Residue SILTY CLAY: Silty clay, trace sand, gray mottled	
			0				4		

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A4-7

TOTAL DEPTH: 4 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/20/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E695497.9 N910052.5

GROUND SURFACE ELEVATION: 631.48

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0 - 4	4		0	0			2	RESIDUE Residue
			0				4	SILTY CLAY: Silty clay with sand lenses, gray

<h1 style="margin: 0;">E N V I R O N</h1> <p style="margin: 0;">740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015</p>					<h2 style="margin: 0;">GEOLOGIC DRILL LOG</h2> <p style="margin: 0;">BOREHOLE NO.: A4-8 TOTAL DEPTH: 8 feet</p>				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/20/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695577.9 N910052.5					GROUND SURFACE ELEVATION: 632.33				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4							RESIDUE: Residue (saturated)	
4 - 8	4		0 0	-5	<div style="display: flex; justify-content: space-between;"> <div>H</div> <div>H</div> <div>H</div> <div>H</div> <div>H</div> <div>H</div> <div>H</div> <div>H</div> <div>H</div> <div>H</div> </div>		SILTY CLAY: Silty clay with sand lenses, gray		

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ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A4-10

TOTAL DEPTH: 8 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/20/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP --

SURVEY LOCATION: E695657.9 N910012.5

GROUND SURFACE ELEVATION: 631.27

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0 - 4	4			0				RESIDUE: Residue
4 - 8	4		0	-5			6	SILTY CLAY: Silty clay with sand lense at -6 ft, brown
			0				8	

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A4-11

TOTAL DEPTH: 4 feet

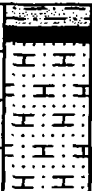
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E695057.9 N99892.5

GROUND SURFACE ELEVATION: 633.17

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4		0	0	H H H H H H H H H H H H		4	SILTY CLAY: Silty clay, some sand, gray and brown mottled

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A4-12 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/19/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695217.9 N909892.5					GROUND SURFACE ELEVATION: 631.58				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0				0.5 0.8 4	SILT: Silty and topsoil, brown RESIDUE: Residue SILTY CLAY: Silty clay, gray and orange-brown mottled	

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A4-13

TOTAL DEPTH: 4 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/20/02

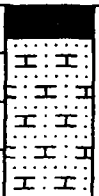
DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E695577.9 N909812.5

GROUND SURFACE ELEVATION: 629.81

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PHD (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0 - 4	4		0				1.5	RESIDUE: Residue
			0				4	SILTY CLAY: Silty clay, gray and brown

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A4-14 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/19/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695257.9 N909772.5					GROUND SURFACE ELEVATION: 630.89				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0	0			0.7	RESIDUE: Residue SILTY CLAY: Silty clay, gray and orange-brown mottled	
			0				4		

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A4-15


TOTAL DEPTH: 4 feet

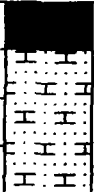
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E695337.9 N99732.5

GROUND SURFACE ELEVATION: 629.88

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4		0				2 4	RESIDUE: Residue SILTY CLAY: Silty clay, gray and orange-brown mottled

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A4-16 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/18/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695497.9 N909732.5					GROUND SURFACE ELEVATION: 629.75				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0 0	0 4			1 4	RESIDUE: Residue SILTY CLAY: Silty clay, gray and orange-brown mottled	

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GEOLOGIC DRILL LOG

BOREHOLE NO.: **A4-17**

TOTAL DEPTH: **8 feet**

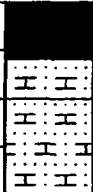
PROJECT:	Eagle Zinc	DRILLING CO.:	Philips
SITE LOCATION:	Hillsboro, IL	RIG TYPE:	Direct Push
JOB NO.:	21-7400E	METHOD OF DRILLING:	Geoprobe
LOGGED BY:	J. Fraser, C. Greco	SAMPLING METHODS:	Macro-core Sampler
DATES DRILLED:	7/18/02	HAMMER WT/DROP:	--

SURVEY LOCATION: **E695297.9 N909652.5**

GROUND SURFACE ELEVATION: **628.12**

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PIID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0 - 4	4		0	0			0	RESIDUE: Residue with intermediate lenses of silty clay
4 - 8	4		0	-5			3	SILTY CLAY: Silty clay, gray with orange-brown mottling (wet below 4 ft)
							8	

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					<div style="text-align: center;"> GEOLOGIC DRILL LOG BOREHOLE NO.: A4-18 TOTAL DEPTH: 4 feet </div>				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/19/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695222.4 N909612.5					GROUND SURFACE ELEVATION: 628.62				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0 0	0			1.2 2 4	RESIDUE: Residue SILTY CLAY: Silty clay, gray SILTY CLAY: Silty clay, orange-brown	

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A4-19


TOTAL DEPTH: 4 feet


PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/18/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E695497.9 N909572.5

GROUND SURFACE ELEVATION: 626.81

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PIID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4		0 0	0			2 4	RESIDUE: Residue SILTY CLAY: Silty clay, brown (soft)

<div style="font-size: 2em; font-weight: bold; letter-spacing: 0.5em;">ENVIRON</div> <div style="font-size: 0.8em;">740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015</div>					<div style="font-size: 1.2em; font-weight: bold;">GEOLOGIC DRILL LOG</div> <div style="font-size: 0.9em;">BOREHOLE NO.: A4-20 TOTAL DEPTH: 8 feet</div>				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/20/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695617.9 N909572.5								GROUND SURFACE ELEVATION: 629.43	
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4						4	RESIDUE: Residue	
4 - 8	4		0 0	-5		8	CLAYEY SILT: Clayey silt, brown and gray		

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: **A4-21**

TOTAL DEPTH: **4 feet**

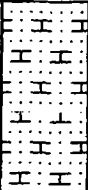
PROJECT: **Eagle Zinc**
SITE LOCATION: **Hillsboro, IL**
JOB NO.: **21-7400E**
LOGGED BY: **J. Fraser, C. Greco**
DATES DRILLED: **7/19/02**

DRILLING CO.: **Phillips**
RIG TYPE: **Direct Push**
METHOD OF DRILLING: **Geoprobe**
SAMPLING METHODS: **Macro-core Sampler**
HAMMER WT./DROP: **--**

SURVEY LOCATION: **E695257.9 N 909492.5**

GROUND SURFACE ELEVATION: **629.43**

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PH (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4		0				1.5	RESIDUE: <i>Residue</i>
			0				4	SILTY CLAY: <i>Silty clay, gray mottled</i>

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: A4-22 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/19/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695377.9 N909412.5					GROUND SURFACE ELEVATION: 624.11				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0 0	0			4	SILTY CLAY: Silty clay, gray, brown and orange mottled	

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: A4-23

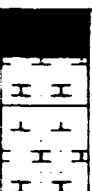
TOTAL DEPTH: 4 feet

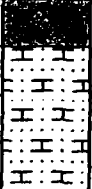
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 7/20/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E695577.9 N909412.5

GROUND SURFACE ELEVATION: 630.1

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0 - 4	4		0 0	0			1 2 4	RESIDUE: Residue SILTY CLAY: Silty clay, trace residue SILTY CLAY: Silty clay, brown

ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015					GEOLOGIC DRILL LOG BOREHOLE NO.: A4-24 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 7/18/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E695297.9 N909372.5					GROUND SURFACE ELEVATION: 623.33				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0 - 4	4		0				1	TOPSOIL: Clayey topsoil, trace residue SILTY CLAY: Silty clay, gray	

ENVIRON

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Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: **A4-25**

TOTAL DEPTH: **4 feet**

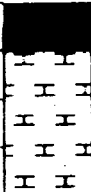
PROJECT: **Eagle Zinc**
SITE LOCATION: **Hillsboro, IL**
JOB NO.: **21-7400F**
LOGGED BY: **J. Fraser, C. Greco**
DATES DRILLED: **7/20/02**

DRILLING CO.: **Philips**
RIG TYPE: **Direct Push**
METHOD OF DRILLING: **Geoprobe**
SAMPLING METHODS: **Macro-core Sampler**
HAMMER WT./DROP: **--**

SURVEY LOCATION: **E695326 N910016.5**

GROUND SURFACE ELEVATION:--

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0 - 4	4		0	0			4	RESIDUE <i>Residue</i>
								SILTY CLAY: <i>Silty clay, brown and gray</i>

ENVIRON

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Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: NA-1

TOTAL DEPTH: 4 feet

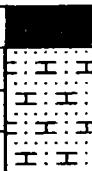
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/17/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 695523.9, N910796.5

GROUND SURFACE ELEVATION: 627.56'

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0		0	0			1.0 4.0	SANDY CLAY: Sandy clay, grey, dry, very stiff. SILTY CLAY: Silty clay, brown, orange-brown mottling, some sand, stiff.
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GEOLOGIC DRILL LOG

BOREHOLE NO.: NA-2

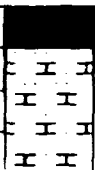
TOTAL DEPTH: 4 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/17/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 694958 N 910696.2

GROUND SURFACE ELEVATION: 632.01'

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0-4	4.0	0		0			1.0 4.0	SANDY CLAY: Sandy clay, brown, some organics, stiff, dry SILTY CLAY: Silty clay, stiff, slightly moist.

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: NA-3 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/17/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 695208 N 910496.2					GROUND SURFACE ELEVATION: 631.15'				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0-4	4.0	0					1.5 4.0	SANDY CLAY: Sandy clay, brown, some organics, stiff, dry. SILTY CLAY: Silty clay, brown, stiff, slightly moist.	

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GEOLOGIC DRILL LOG

BOREHOLE NO.: NA-4

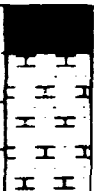
TOTAL DEPTH: 4 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/17/02

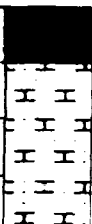
DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

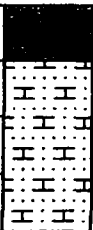
SURVEY LOCATION: E 696008 N 910496.2

GROUND SURFACE ELEVATION: 625.07'

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0	4.0		0	0			10	SANDY CLAY: Sandy clay, light brown, some organics, stiff, dry
							40	SILTY CLAY: Silty clay, brown, some sand, medium stiff, moist

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: NA-5 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/17/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT/DROP: --				
SURVEY LOCATION: E 696208 N 910496.2					GROUND SURFACE ELEVATION: 627.52'				
SS INTERVAL (ft)	SS RECOVERY (ft)	BLOW COUNTS	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0-4	4.0		0	0			1.0	SANDY CLAY: Sandy clay, light brown, some organics, stiff, dry. SILTY CLAY: Silty clay, brown, some sand, medium stiff, moist.	

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: NA-6 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/17/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Casprabe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 696358 N 910346.2					GROUND SURFACE ELEVATION: 629.16'				
SS INTERVAL (ft)	SS RECOVERY (%)	BLOW COUNTS	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0.4	4.0			0			1.0	SANDY CLAY: Sandy clay, light brown, some organics, stiff, dry. SILTY CLAY: Silty clay, orange-brown mottling, medium stiff, moist.	

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: NA-7 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/17/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 695734.9 N 910272.3					GROUND SURFACE ELEVATION: 627.68'				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0-4	4.0		0				1.0	SANDY CLAY: Sandy clay, brown, little organics, dry. SILTY CLAY: Silty clay, orange-brown mottling, trace sand, stiff, moist.	

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GEOLOGIC DRILL LOG

BOREHOLE NO.: NA-8

TOTAL DEPTH: 4 feet

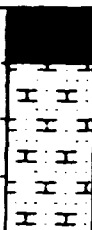
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/17/02

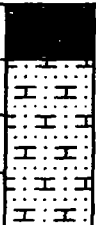
DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT/DROP: --

SURVEY LOCATION: E696187.9 N 910246.3

GROUND SURFACE ELEVATION: 623.08'

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0.4	4.0	S-NA-8-2	0	0			1.0	SANDY CLAY: Sandy clay, light brown, organics, dry. SILTY CLAY: Silty clay, brown mottling, stiff, moist.
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ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015					GEOLOGIC DRILL LOG BOREHOLE NO.: NA-9 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/17/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 696058 N 910046.2					GROUND SURFACE ELEVATION: 629.4'				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0-4	4.0	S-NA-9-2 S-NA-9-2D	0	0			1.0	SANDY CLAY: Sandy clay, light brown, organics, stiff, dry. SILTY CLAY: Silty clay, orange-brown mottling, trace sands, stiff, moist.	

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GEOLOGIC DRILL LOG

BOREHOLE NO.: NA-10

TOTAL DEPTH: 4 feet


PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
HMR NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/17/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 696465.8 N 910046.2

GROUND SURFACE ELEVATION: 627.38'

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0		0	0			1.5	SANDY CLAY: Sandy clay, brown, dry. SILTY CLAY: Silty clay, orange-brown mottling, stiff, moist.
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ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: WA-1

TOTAL DEPTH: 4 feet

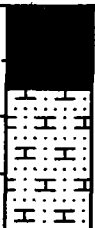
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/17/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP --

SURVEY LOCATION: E 694964.3 N 910292.5

GROUND SURFACE ELEVATION: 633.52'

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0		0	0			1.5	SANDY CLAY: Sandy clay, light brown, stiff, dry. SILTY CLAY: Silty clay, orange-brown mottling, stiff, moist.
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ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: WA-2

TOTAL DEPTH: 4 feet

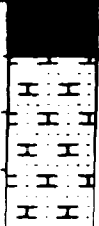
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/17/02

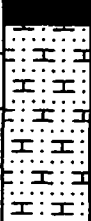
DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 695177.3 N 909772.5

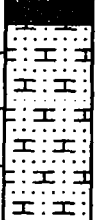
GROUND SURFACE ELEVATION: 631.4'

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PIU (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0			0			1.0	SANDY CLAY: Sandy clay, light brown, stiff, dry. SILTY CLAY: Silty clay, orange-brown mottling, stiff, moist
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<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: WA-3 TOTAL DEPTH: 4 feet			
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/17/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --			
SURVEY LOCATION: E 694924.3 N 909639.5					GROUND SURFACE ELEVATION: 632.7'			
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0-4	4.0		0	0			0.5	SANDY CLAY: Sandy clay, brown, stiff, dry. SILTY CLAY: Silty clay, brown, moist.

ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015					GEOLOGIC DRILL LOG BOREHOLE NO.: WA-4 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/17/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 694884.3 N 909532.5					GROUND SURFACE ELEVATION: 630.71'				
SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0-4	4.0		0	0			0.5	SANDY CLAY: Sandy clay, light brown, stiff, dry. SILTY CLAY: Silty clay, brown mottling, stiff, moist.	

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: WA-5 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/17/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 695194.5 N909332.2					GROUND SURFACE ELEVATION: 622.51'				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0.4	4.0	0		0			0.5	SANDY CLAY: Sandy clay, brown, stiff, dry. SILTY CLAY: Silty clay, grey, orange-brown mottling, stiff, moist.	

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GEOLOGIC DRILL LOG

BOREHOLE NO.: **WA-6**

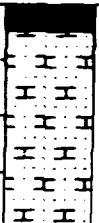
TOTAL DEPTH: 4 feet

PROJECT:	Eagle Zinc
SITE LOCATION:	Hillsboro, IL
JOB NO.:	21-7400E
LOGGED BY:	J. Fraser, C. Greco
DATES DRILLED:	07/17/02

DRILLING CO.:	Philips
RIG TYPE	Direct Push
METHOD OF DRILLING:	Geoprobe
SAMPLING METHODS:	Macro-core Sampler
HAMMER WT./DROP	--

SURVEY LOCATION: E695084 J N 909212.5

GROUND SURFACE ELEVATION: 621.99'

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0-1	4.0		0	0			0.5	SANDY CLAY: <i>Sandy clay, brown, stiff, dry.</i> SILTY CLAY: <i>Silty clay, grey, orange-brown mottling, stiff, moist.</i>

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: **WA-7**

TOTAL DEPTH: **4 feet**

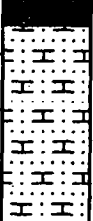
PROJECT: **Eagle Zinc**
SITE LOCATION: **Hillsboro, IL**
JOB NO.: **21-7400E**
LOGGED BY: **J. Fraser, C. Greco**
DATES DRILLED: **07/17/02**

DRILLING CO.: **Philips**
RIG TYPE: **Direct Push**
METHOD OF DRILLING: **Geoprobe**
SAMPLING METHODS: **Macro-core Sampler**
HAMMER WT/DROP: **--**

SURVEY LOCATION: **E 694960.7 N 909175.8**

GROUND SURFACE ELEVATION: **625.44'**

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0		0				0.5	SANDY CLAY: Sandy clay, dark brown, some organics, stiff. SILTY CLAY: Silty clay, brown mottling, stiff, moist.
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ENVIRON

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Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: WA-8

TOTAL DEPTH: 8 feet

PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
NR NO: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/17/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT / DROP: --

SURVEY LOCATION: E695084.9 N 988998

GROUND SURFACE ELEVATION: 619.4'

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0	S-NA-8-2	0	0			1.5	SANDY CLAY: Sandy clay, brown, stiff, dry.
							4	SILTY CLAY: Silty clay, dark brown, soft, very moist.
4-8	4.0		0	-5			8	SILTY CLAY: Silty clay, brown, medium stiff, moist.

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: **WA-9**

TOTAL DEPTH: **11 feet**

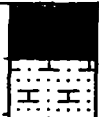
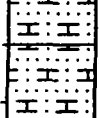
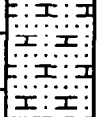
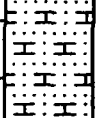
PROJECT: **Eagle Zinc**
SITE LOCATION: **Hillsboro, IL**
JOB NO.: **21-7400E**
LOGGED BY: **J. Fraser, C. Greco**
DATES DRILLED: **07/17/02**

DRILLING CO.: **Philips**
RIG TYPE: **Direct Push**
METHOD OF DRILLING: **Geoprobe**
SAMPLING METHODS: **Macro-core Sampler**
HAMMER WT./DROP: **--**

SURVEY LOCATION: **E 694804.2 N 908578.5**

GROUND SURFACE ELEVATION: **612.15'**

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0	S-NA-9-2 S-NA-9-2D	0	0			1.0	SANDY CLAY: Sandy clay, grey, stiff, dry.
4-8	4.0		0	-5			3.0	SILTY CLAY: Silty clay, orange-brown mottling, stiff, moist.
8-12				-10			6.5	SILTY CLAY: Silty clay, dark brown, very soft, moist.
								SILTY CLAY: Silty clay, brown mottling, stiff, moist.

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: WA-10

TOTAL DEPTH: 4 feet

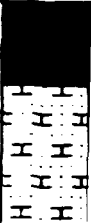
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/17/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 695064.3 N 908372.5

GROUND SURFACE ELEVATION: 618.73'

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0		0				1.5	RESIDUE: Residue. SILTY CLAY. Silty clay, brown mottling, stiff, moist.
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<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: MA-3 TOTAL DEPTH: 8 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/17/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Ceoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 695839.8, N 909620.5					GROUND SURFACE ELEVATION: 632.28'				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0-4	4.0		0					RESIDUE: Residue	
4-8	4.0		0			5.0	SILTY CLAY: Silty clay, brown, mottling, moist, stiff.		

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GEOLOGIC DRILL LOG

BOREHOLE NO.: MA-4

TOTAL DEPTH: 8 feet


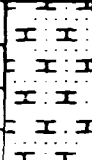
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7480E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/17/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT/DROP: --

SURVEY LOCATION: E 695909.8, N 909258.1

GROUND SURFACE ELEVATION: 634.62'

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0		0	0				RESIDUE: Residue
4-8	4.0		0	-5			4.0	SILTY CLAY: Silty clay, brown, mottling, med. stiff.

ENVIRON

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GEOLOGIC DRILL LOG

BOREHOLE NO.: MA-5

TOTAL DEPTH: 4 feet


PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/17/02

DRILLING CO.: Philips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT./DROP: --

SURVEY LOCATION: E 696189.8, N 909270.5

GROUND SURFACE ELEVATION: 631.96

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0		0	0			2.0	RESIDUE: Residue SILTY CLAY: Silty clay, brown, mottling, moist.
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GEOLOGIC DRILL LOG

BOREHOLE NO.: MA-6

TOTAL DEPTH: 8 feet


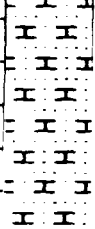
PROJECT: Eagle Zinc
SITE LOCATION: Hillsboro, IL
JOB NO.: 21-7400E
LOGGED BY: J. Fraser, C. Greco
DATES DRILLED: 07/17/02

DRILLING CO.: Phillips
RIG TYPE: Direct Push
METHOD OF DRILLING: Geoprobe
SAMPLING METHODS: Macro-core Sampler
HAMMER WT/DROP: --

SURVEY LOCATION: E 695954.9, N 909005

GROUND SURFACE ELEVATION: 633.22'

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
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0-4	4.0		0	0			2.5	RESIDUE: Residue
4-8	4.0		0	-5				SILTY CLAY: Silty clay, brown, moist, stiff, some sand.

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GEOLOGIC DRILL LOG

BOREHOLE NO.: **MA-7**

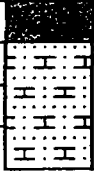
TOTAL DEPTH: **4 feet**

PROJECT: **Eagle Zinc**
SITE LOCATION: **Hillsboro, IL**
JOB NO.: **21-7400E**
LOGGED BY: **J. Fraser, C. Greco**
DATES DRILLED: **07/17/02**

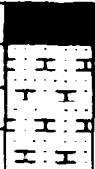
DRILLING CO.: **Phillips**
RIG TYPE: **Direct Push**
METHOD OF DRILLING: **Geoprobe**
SAMPLING METHODS: **Macro-core Sampler**
HAMMER WT./DROP: **--**


SURVEY LOCATION: **E 696263.8, N 908820.5**



GROUND SURFACE ELEVATION: **627.02'**

SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0-4	4.0		0	0			1.0	TOPSOIL: Top soil, organics. SILTY CLAY: Silty clay, brown with orange-brown mottling, moist.

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<div style="text-align: center;"> ENVIRON 740 Waukegan Rd. Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: MA-8 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/17/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT/DROP: --				
SURVEY LOCATION: E 695989.8, N 908756.9					GROUND SURFACE ELEVATION: 631.89'				
SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0	4.0		0	0			10	RESIDUE: Residue SILTY CLAY: Silty clay, brown, mottling, some sand, moist.	

ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015					GEOLOGIC DRILL LOG BOREHOLE NO.: MA-1 TOTAL DEPTH: 4 feet			
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/17/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --			
SURVEY LOCATION: E 695739.8, N 909920.5					GROUND SURFACE ELEVATION: 631.89'			
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0-4	4.0		0				2.0	RESIDUE: Residue <hr/> SILTY CLAY: Silty clay, stained black, soft, moist.

<div style="text-align: center;"> <h1>ENVIRON</h1> <p>740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015</p> </div>					<h2>GEOLOGIC DRILL LOG</h2> <p>BOREHOLE NO.: MA-2 TOTAL DEPTH: 4 feet</p>			
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/17/02					DRILLING CO.: Phillips RIG TYPE: Direct Push METHOD OF DRILLING: Ceaprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --			
SURVEY LOCATION: E 696189.8, N 908570.5					GROUND SURFACE ELEVATION: 629.46'			
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0-4	4.0		0		 		2.0	RESIDUE: Residue SILTY CLAY: Silty clay, brown, mottling, moist, some sand.

<div style="text-align: center;"> ENVIRON 740 Waukegan Rd., Suite 401 Deerfield, Illinois 60015 </div>					GEOLOGIC DRILL LOG BOREHOLE NO.: MA-9 TOTAL DEPTH: 4 feet				
PROJECT: Eagle Zinc SITE LOCATION: Hillsboro, IL JOB NO.: 21-7400E LOGGED BY: J. Fraser, C. Greco DATES DRILLED: 07/17/02					DRILLING CO.: Philips RIG TYPE: Direct Push METHOD OF DRILLING: Geoprobe SAMPLING METHODS: Macro-core Sampler HAMMER WT./DROP: --				
SURVEY LOCATION: E 695989.8, N 908605.1					GROUND SURFACE ELEVATION: 632.94'				
SS INTERVAL (ft)	SS RECOVERY (ft)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION	
0-4	4.0		0	0			0.5	RESIDUE: Residue SILTY CLAY: Silty clay, brown with mottling, some sand, medium stiff.	

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ENVIRON

740 Waukegan Rd., Suite 401
Deerfield, Illinois 60015

GEOLOGIC DRILL LOG

BOREHOLE NO.: **MA-10**


TOTAL DEPTH: **4 feet**

PROJECT: **Eagle Zinc**
SITE LOCATION: **Hillsboro, IL**
JOB NO.: **21-7400E**
LOGGED BY: **J. Fraser, C. Greco**
DATES DRILLED: **07/17/02**

DRILLING CO.: **Phillips**
RIG TYPE: **Direct Push**
METHOD OF DRILLING: **Geoprobe**
SAMPLING METHODS: **Macro-core Sampler**
HAMMER WT/DROP: **--**

SURVEY LOCATION: **E 6963898, N 908570.5**

GROUND SURFACE ELEVATION: **624.98'**

SS INTERVAL (ft)	SS RECOVERY (%)	SAMPLE ID	PID (ppm)	DEPTH (ft)	GRAPHIC LOG	USCS	LAYER DEPTH (ft)	SOIL DESCRIPTION
0-4	4.0		0	0			1.0	TOPSOIL: Top soil, organics. SILTY CLAY: Silty clay, brown with orange-brown mottling, moist.